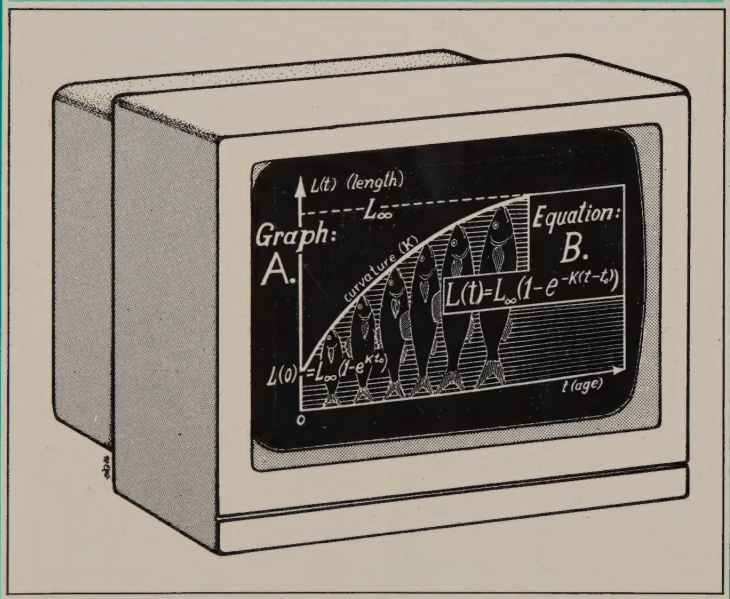
Computer programs for fish stock assessment

Length-based Fish Stock Assessment for Apple II computers



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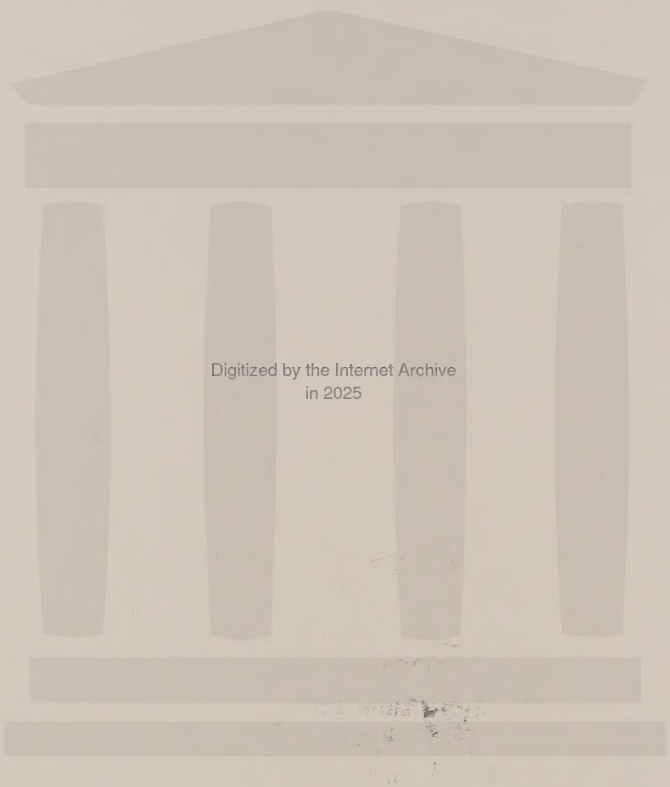

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Computer programs for fish stock assessment

Length-based Fish Stock Assessment for Apple II* computers

by
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PREPARATION OF THIS DOCUMENT

This manual was prepared by the author while working as a consultant to FAO, and in part, it reflects his experience as a lecturer in training in fish stock assessment under the FAO/DANIDA training project, GCP/INT/392/DEN. The report is primarily intended for scientists in fisheries who already have a broad familiarity with the theory of fish stock assessment, and in particular, addresses those methodologies recently coming into widespread use for analysis of length frequency distribution which lead directly to analytical assessments of fish stocks.

The package was prepared originally in BASIC on the PRODOS system for use with an Apple IIc microcomputer, but the programs should be readily convertible for use with other machines. At least one other version for IBM XT (and its compatibles) is now available.

The manual is distributed without the three diskettes containing the BASIC programs. The diskettes can be requested to FAO sending the form given in the last page of the manual and 3 blank diskettes in exchange. The programs will also be made available to the software users networks, such as those listed in the form.

Any technical difficulties encountered in the use of these programs should be inferred to a competent programmer, and in the last resort can be addressed to the author.

The present report is one of a series discussing stock assessment routines in different programming languages, and follows FAO attempts to update an earlier program compilation (1) and to document available routines in stock assessment (2), which have so far led to a selection of key programs to FORTRAN being compiled (3) for use on main frame computers and with HP-41C programmable calculators (4).

Present address: FAO, Fisheries Department
Marine Resources Service
Via delle Terme di Caracalla, 00100 Rome, Italy

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(1) Abramson, N.J., 1971 Computer programs for fish stock assessment. FAO Fish.Tech.Pap., (101):148 p.

(2) Caddy, J.F., 1982 Provisional world list of computer programs for fish stock assessment and their availability by country and fisheries institute. FAO Fish.Circ. (756):51 p.

(3) Sims, S.E., 1985 Selected computer programs in FORTRAN for fish stock assessment. FAO Fish.Tech.Pap., (259): 183 p.

(4) Vakily, J.M., 1986 M.L. Palomares and D. Pauly, Computer programs for fish stock assessment: HP 41 CV calculator. Produced with the cooperation of the International Center for Living Aquatic Resources Management (ICLARM). FAO Fish.Tech. Pap., (101)Suppl.1:255 p.

ABSTRACT

The present package of BASIC programs for the micro computer Apple II (based on the 6502 eight bit microprocessor) is intended for tropical fish stock assessment.

Emphasis has been placed on the analysis of time series of body length frequency samples.

In addition the package contains programs for analysis of age/length frequencies, yield per recruit analysis and ordinary regression analysis.

The programs work interactively by aid of menus. They do not require special knowledge of micro computers.

The length frequency analysis consists in three main groups of programs:

1. Handling of length frequency data (storing on diskettes and data manipulations).
2. Estimation of growth parameters by model progression analysis (composed of Bhattacharya analysis, Gulland and Holt plot and von Bertalanffy plot).
3. Estimation of mortality rates (length converted catch curve, estimation of selection ogives, cumulated catch curve analysis, Jones' length converted cohort analysis).

DISCLAIMER:

The programs contained in this publication are furnished without warranty. Neither the author of the programs, the institutions which supply them, the editor, nor FAO make any representation as to the accuracy or completeness of the information or programs and assume no responsibility with respect to their use.

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PREFACE

The present version of the package of micro computer BASIC programs for tropical Fish Stock Assessment (the "LFSA-package") is intended to be number one in a series of versions and may still contain some bugs.
It is expected that improvements and extensions will emerge after the package has been applied in practice and a number of new and improved versions are foreseen.
Constructive criticism, suggestions and comments will be highly appreciated by the author.

The package is implemented for the micro computer APPLE II (e or c). This does not imply that APPLE II products are recommended in preference to other products, and evidently there exists a number of micro computers on the market which also would fit the purpose. Some of them are based on the same microprocessor as APPLE II (6502A or 65C02) and some are based on more powerful ones. In particular, work is in progress on preparation of a package in IBM-compatible format.

ACKNOWLEDGEMENT

I wish to express my gratitude to J.F. Caddy (FAO, Rome), who provided the initiative to start this work, and K. Brander (Fisheries Laboratory, Lowestoft, U.K.) for reviewing the manuscript and programs and for giving many valuable suggestions.

I also wish to express my gratitude to the participants in the FAO/DANIDA training course in fish stock assessment in Hirtshals (Denmark) May 1986 for acting as the first "test animals" of the LFSA package (which at that time was still under development). They did a great job in finding bugs and I received many good suggestions from them.

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1. INTRODUCTION

This package of Length-based Fish Stock Assessment (LFSA) programs is implemented for the micro-computers APPLE IIe and APPLE IIc, and is intended for use by workers in tropical fish stock assessment.

As far as possible the programs are intended to be self explanatory, i.e. if you are familiar with the methods handled by the LFSA package you should not need to spend much time on reading this manual (and if you are not familiar with the methods you should not use the LFSA package).

This, of course, applies only to users with some experience in the use of micro-computers.

This manual is primarily intended for beginners in the use of micro-computers, and for people who want to assess the LFSA package before they decide to use (or not to use) it. However, if you are an experienced user the manual may prove useful as a reference manual.

1.1. BACKGROUND OF THE FISH STOCK ASSESSMENT (LFSA) PACKAGE

The selection of methods and models handled by the LFSA package is based on my experience as a lecturer in the FAO/DANIDA project on training in tropical fish stock assessment (GCP/INT/392/DEN). By now (September 1986) this project has delivered two international courses: in Kenya 1983 for participants from the countries of the Western Indian Ocean, in Denmark 1984 for participants from West Africa and the Caribbean Area and in Denmark 1986 for both regions. Five national courses have been given in: India, 1983, Malaysia, 1984, Indonesia, 1984, Thailand, 1985 and Philippines 1986. During these courses participants were invited to present their national data and to discuss ways of processing the data. The methods taught on the courses were adopted to match the data available (or data which could relatively easy be made available). Most of the methods presented on the courses are summarized in the lecture notes:

Sparre, P., 1985 Introduction to tropical fish stock assessment. Based on preliminary versions of lecture notes prepared by the team of lecturers in the FAO/DANIDA Project training in fish stock assessment, GCP/INT/392/DEN. Rome, FAO, Denmark Funds-in-Trust, GCP/INT/392/DEN, Manual 1:338 p.

_____, 1985 Introduction to tropical fish stock assessment. Part 2: Solutions to exercises. Based on preliminary versions of lecture notes prepared by the team of lecturers in the FAO/DANIDA Project training in fish stock assessment, GCP/INT/392/DEN. Rome, FAO, Denmark Funds-in-Trust, GCP/INT/392/DEN, Manual 1, Pt. 2, pp. 339-84

Most methods presented in these lecture notes are designed to be carried out using a particular pocket calculator which all participants were given by the project. However, fish stock assessment based on large data sets using a pocket calculator is somewhat tedious and often very difficult.

Basically, the present package of micro-computer programs aims at solving the same problems as those presented in the lecture notes. The main advantages of the micro-computer compared to the pocket calculator are:

A. Time taken for data processing considerably reduced.

B. Risk of miscalculations minimized.

C. Reanalysis of data made easy.

Item C is especially important. Once the data are stored on magnetic diskettes, it is an easy task to retrieve them and repeat the analysis based on new knowledge and/or different assumptions.

1.2. OBJECTIVES OF THE LFSA PACKAGE

From experience gained during the FAO/DANIDA training courses and elsewhere it appears that length frequency data, (e.g. number of fish caught per cm. length group per time unit) are available and are collected on a routine basis in many tropical countries.

The basic input data for fish stock assessment in temperate waters, i.e. age frequency data, are rarely collected in tropical waters, because of the difficulties involved in reading ring structures in hard parts of the fish (otoliths or scales).

This package for tropical fish stock assessment therefore concentrates on the analysis of length frequency data, although some of the traditional methods of temperate fish stock assessment are (or will be) included in LFSA package.

The objective of the LFSA package is to facilitate the data processing currently carried out by experienced workers in tropical fish stock assessment.

This LFSA package is not intended for beginners in fish stock assessment. Before you start using the package you must have obtained a good understanding of the methods, e.g. by doing the calculations by paper and pencil (and pocket calculator).

As already mentioned, the LFSA package follows the lecture notes used during the FAO/DANIDA courses. However, not all methods dealt with in the courses are included in the LFSA package. Some methods are so simple from a calculational point of view that they do not require their own program (such methods are in most cases covered by the general purpose programs).

Other methods, such as the ELEFAN I method, are already represented in other packages of micro-computer programs (Pauly & David, 1981 and Saeger & Gayanilo, 1985).

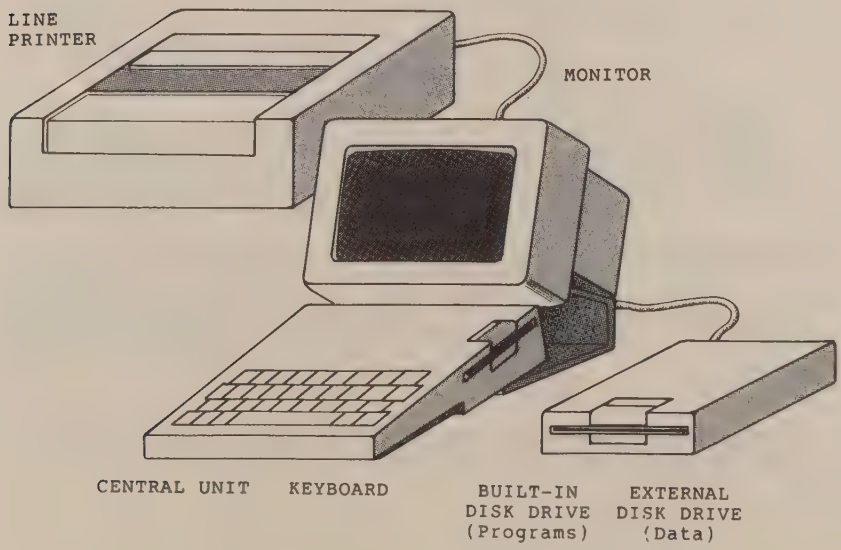
2. GENERAL FEATURES OF THE LFSA PACKAGE.

Section 2 presents a number of general points which apply to all programs of the LFSA package.

2.1 HARDWARE.

The LFSA package is implemented for the micro computers APPLE IIe and APPLE IIc (The latter was used by the author). The system required consists of :

1. APPLE II Central Unit with 128 K bytes of RAM and with the 80 columns text card.
2. Monitor.
3. Two floppy disk (5 1/4 inc.) drives.
4. Line printer for A4-format paper.



2.2. SOFTWARE.

The LFSA package is written in the computer language APPLESOFT BASIC and uses the disk operating system PRODOS.

There is no need for a profound knowledge of the BASIC language or the disk operating system before you start using the LFSA package.

The diskette containing the PRODOS disk operating system must be loaded into the computer before you can run the LFSA package. This diskette is called the "STARTUP DISKETTE" and the startup procedure will be explained in Section 2.7.

A few PRODOS and BASIC commands which may be useful for you to know about are :

CONTROL-C : Stops the execution of a running program. (If you type the letter C while holding down the CONTROL-key when a program is running the execution is aborted). The computer will respond by giving a beep and write on the screen : "BREAK IN XXXX", where XXXX stands for some BASIC program line number, which you can ignore.

CONTROL-S : Suspends the screen output. If you type the letter S while holding down the CONTROL-key when a program is displaying output the listing is suspended. You resume the listing by another CONTROL-S.

RUN : Restart a program interrupted by CONTROL-C. Any data you have entered to the program before you abort it will be lost. Thus, when using the RUN command you will start from scratch. You just write "RUN" and press the RETURN-key.

RUN PN,D1 : "PN" stands for "Program Name" and ",D1" is the name APPLE II uses for disk drive no. one. This command loads a program from the program diskette and starts the execution. "Program name" is the name of the program you want to run. In the list of contents the program names are the text in capital letters in brackets.

It should be noticed that the entire LFSA package can be run without the use of any BASIC or PRODOS commands

Together with the APPLE computer goes a diskette and a manual with

SYSTEM UTILITIES

This is a package of programs by which you can name diskettes, copy whole diskettes or files. Needles to say, this package is very useful, and it is recommended that you learn how to use it.

2.3. GENERAL STRUCTURE OF THE LFSA PACKAGE.

The Fish Stock Assessment (LFSA) package is divided into four sub-packages according to the type of input data required by the programs :

LF. LENGTH FREQUENCY ANALYSIS (LF) SUB-PACKAGE.
Input data are single samples or time series of body length frequencies i.e. number of fish per length group.

AL. AGE/LENGTH DATA (AL) SUB-PACKAGE.
Input data are pairs of age and length measurements. Age could be measured from ring structures of hard parts.

PA. SUBPACKAGE OF PROGRAMS USING PARAMETERS AS INPUT.
E.g. the Beverton and Holt yield per recruit model

GEN. GENERAL PURPOSE PROGRAMS.
E. g. ordinary linear regression analysis.

In addition there is the STARTUP diskette (Cf. Section 2.10).

Within a sub-package the programs interact in the sense that output from one program can act as input to another program. Except for the programs used for entering of raw data from the key board this is always the case.

The floppy diskettes are used to store data or results between the execution of two consecutive programs.

Because of the limited memory available in the Apple II micro computer this splitting of the computational process is unavoidable.

A collection of information (raw data or processed data) you store on a disk is called a "file".
The size of APPLE II also puts limits on the number of data you can handle in one go. Thus, if you have a large data set (say, 200 length frequency samples) you will have to distribute them on a number of files. For the final processing you will usually poole the data, and thereby obtain data files of a size which can be handled in one program run.

The typical set-up of such a suite of connected programs is illustrated in Figure 2.3.1.

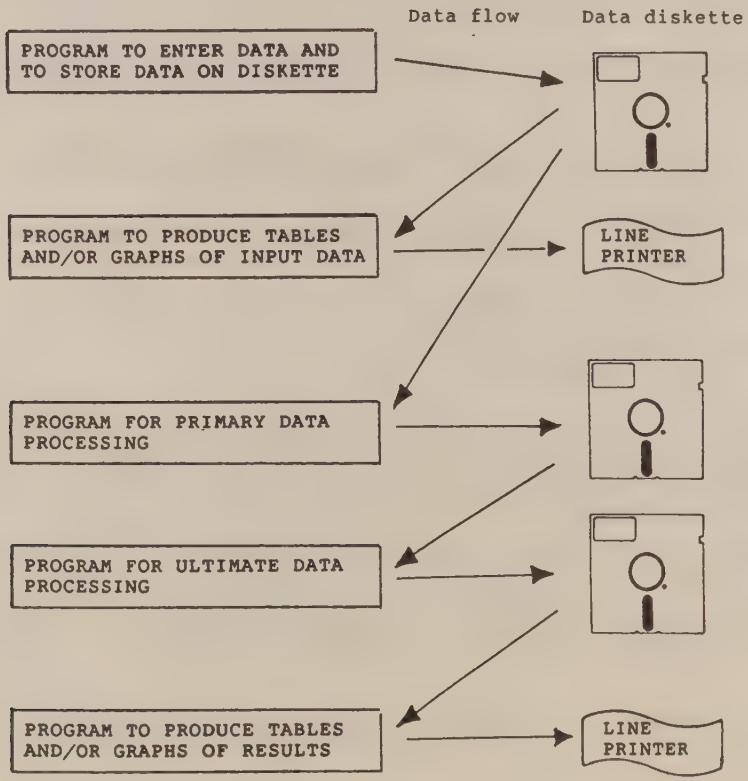

Data flow
Data diskette
PROGRAM TO ENTER DATA AND TO STORE DATA ON DISKETTE
PROGRAM TO PRODUCE TABLES AND/OR GRAPHS OF INPUT DATA
LINE PRINTER
PROGRAM FOR PRIMARY DATA PROCESSING
PROGRAM FOR ULTIMATE DATA PROCESSING
PROGRAM TO PRODUCE TABLES AND/OR GRAPHS OF RESULTS
LINE PRINTER

Figure 2.3.1. The typical set-up of a suite of programs.

The programs are stored on a "program diskette" and are loaded from the diskette into the computer in a sequence of the users choice.
The user selects the programs from the program diskette by aid of a socalled "menu-program".
A "menu-program" is a program which can display a list of programs (the "courses") on the screen, let the user choose a program and then retrieve the program from the program diskette.

How the menu-programs work is explained in next sub-section.

2.4. GENERAL FEATURES ABOUT THE PROGRAMS.

The programs works interactively by prompting questions on the screen to the user who in turn replies by entering the answers from the keyboard.
Whenever applicable the questions are given in the form of a "menu".
A "menu" is a list of options ("courses") from which the user selects the option she/he wants.

As an example one of the menus from the menu-program for length frequency analysis (LFMENU) is shown below, exactly as it appears on the screen

```
--------------------------- SD 1 ---------------------------------
!                                                                 !
!    ********************************************               !
!    **                F.A.O                     **             !
!    ** PACKAGE OF FISH STOCK ASSESSMENT PROGRAMS **             !
!    **         LENGTH FREQUENCY ANALYSIS        **             !
!    ********************************************               !
!                                                               !
!               DATA HANDLING  M E N U                          !
!                                                               !
!  1 : ENTER NEW FILE OR CHANGE OLD FILE (Ordinary lgt. frq.)   !
!                                        LFINPUT                !
!  2 : ENTER NEW FILE OR CHANGE OLD FILE (Data which require    !
!      a conversion. E.g. fork length to total length)          !
!                                        LFCONV                 !
!  3 : MANIPULATION OF EXISTING FILES.   LFMANI,LFMERG,LFCONV   !
!  4 : DISPLAY OF BAR DIAGRAMS           LFBAR                  !
!  5 : DISPLAY OF TABLES                 LFTABLE                !
!  6 : ENTER ADDITIONAL DATA             LFINF                  !
!  7 : ADD SAMPLES                       LFSUM                  !
!  8 : QUIT (Return to main menu)                               !
!                                                               !
!    Choose option ! 3 !                                        !
!                                                               !
--------------------------- SD 1 ---------------------------------
```

This particular menu is used to select a program among the group of programs dealing with "data handling" of length frequencies.

The only thing you need do is to enter from the keyboard the number of the selected program. If you select program no. 3 then the figure "3" appears on the screen as indicated by the squared frame. This frame is not shown on the screen. It is used only in the manuals to distinguish the text produced by the computer from the text entered by the user via the keyboard.
After entering the number of the selected program, you terminate the screen session by pressing the RETURN-key. The program may now react in three different ways :

1 : Load a program from the diskette and start to execute it.
2 : Display a new sub-menu.
3 : Ask you to insert another program diskette in the disk drive.

In the present case the program will display a new sub-menu, because there are several programs which deal with data manipulation. The new sub-menu looks like :

```
---------------------------- SD 2 -----------------------------
!                                                             !
!          MANIPULATION OF EXISTING FILES                     !
!                                                             !
!    1 : Manipulation of data from one file       LFINPUT     !
!          (Conversion into relative frequencies)             !
!          (Change interval size)                             !
!          (Weighted summation of samples)                    !
!          (Change lower limit of first lgt. gr.)             !
!                                                             !
!    2 : Merging of files.                        LFMERGE     !
!                                                             !
!    3 : Conversion of data. E.g. :               LFCONV      !
!          Fork length into total length,...,etc.             !
!          Unequal intervals into equal intervals.            !
!          Weight intervals into length intervals.            !
!                                                             !
!    4 : QUIT (Return to menu)                                !
!                                                             !
!      Choose option  ! 1 !                                   !
!                                                             !
---------------------------- SD 2 -----------------------------
```

you then select, say, option 1 from this menu. The program diskette will start to whirl and a program which can perform the operations specified under option 1 will be loaded into the computer and will automatically start the execution.

An example of a menu displayed during the execution of a data processing program is the SD 3 (screen display example no. 3.) In this case the menu contains a "default option", i.e. an option which is executed if you press only the RETURN-key. In the case of SD 3 the default option executes three of the op-tions.
Whenever possible the program tries to predict the choice of the user and to offer this as the default option.
In some cases a program can be executed almost only by using the RETURN-key. As will appear after some execises with the package you can save a lot of time and avoid mistakes by using the de-fault option.

Now, suppose that we were running the program for the "Length converted catch curve" and had finished the calculations so that screen display 3 appeared. The effect of using the default option is illustrated in SD 4.
Forget for the time being what the meaning of the table in SD 4 is. Notice only that the table contains 25 lines. The screen can contain at most 24 lines at a time.
When a display requires more than 24 lines the program presents the display in portions. You proceed from one portion to the next by pressing the RETURN-key.
In the case of SD 4 the program will start by showing the first portion which in this case is the first 18 lines (until the blank line finished by RETURN). After pressing the RETURN-key the last 7 lines will emerge and the two first lines will disappear (since there is space for only 24 lines).

It may be difficult to survey a result in portions and if you don't like that you should ask for a printed version (e.g. by choosing option 10).

With SD 4 we have executed option 1. To proceed to option 3 (re-call that the default option we selected included options 1, 3 and 5) we press the RETURN-key and next screen display (which is not shown here) gives the plot.

This is a general rule :

WHENEVER THE COMPUTER IS WAITING BUT NOT PROMPTING A QUESTION YOU PROCEED BY PRESSING THE RETURN-KEY.

This is in order to allow you as much time as you like for loo-king at the screen display.

If in the example of SD 3 you select an option different from the quit-option (Option 11) you will return to the menu after the execution of the option. You can return and repeat options as many times as you like.

```
------------------------- SD 3 --------------------------
!                                                       !
!   - - LENGTH CONVERTED CATCH CURVE ANALYSIS - -       !
!                                                       !
!  1 : Print input table on screen                      !
!  2 : Print input table on printer                     !
!  3 : Print catch curve on screen                      !
!  4 : Print catch curve on printer                     !
!  5 : Print results of catch curve analysis on screen  !
!  6 : Print results of catch curve analysis on printer !
!  7 : Print details of regression analysis on screen   !
!  8 : Print details of regression analysis on printer  !
!  9 : Redo analysis with same input data               !
!      (e.g. with new v.B. param.)                      !
! 10 : Print all results on PRINTER (Options 2,4,6 and 8)!
! 11 : Quit (Continue with estimation of SELECTION OGIVE)!
!                                                       !
! Choose option (default = 1,3 and 5) !RETURN!          !
!                                                       !
------------------------- SD 3 --------------------------
```

```
------------------------- SD 4 --------------------------
!                                                       !
! Interval        C        dt        t       log(C/dt)  !
! ----------------------------------------------------- !
!  7- 8          11   I   0.0759    0.4890     4.9758   !
!  8- 9          69   I   0.0796    0.5667     6.7648   !
!  9-10         187   I   0.0836    0.6483     7.7122   !
! 10-11         133   I   0.0881    0.7341     7.3194   !
! 11-12         144   I   0.0931    0.8247     7.1102   !
! 12-13         261   I   0.0986    0.9205     7.8804   !
! 13-14         386   I   0.1049    1.0222     8.2099   !
! 14-15         445   I   0.1121    1.1306     8.2863   !
! ----------------------------------------------------- !
! 15-16         535   I   0.1203    1.2467     8.4000   !
! 16-17         407   I   0.1297    1.3716     8.0506   !
! 17-18         428   I   0.1409    1.5067     8.0188   !
! 18-19         338   I   0.1540    1.6539     7.6933   !
! 19-20         184   I   0.1700    1.8155     6.9869   !
! 20-21          73   I   0.1895    1.9948     5.9534   !
! 21-22          37   I   0.2142    2.1959     5.1515   !
!                                                !RETURN! !
! 22-23          21   I   0.2463    2.4251     4.4455   !
! 23-24          19   I   0.2897    2.6914     4.1831   !
! 24-25           8   I   0.3518    3.0092     3.1239   !
! ----------------------------------------------------- !
! 25-26           7   I   0.4480    3.4033     2.7488   !
! 26-27           2   I   0.6172    3.9224     1.1755   !
!                                                !RETURN! !
!                                                       !
------------------------- SD 4 --------------------------
```

But it is far from always so that the computer waits for you. Often you will have to wait for the computer.
Because APPLE II is a slow computer you must often patiently wait for it to complete some task.
E.g. it takes the computer some time to produce, say, a bar diagram. If you run the bar diagram producing program, LFBAR, you will see SD 5.
Similar displays appear during the execution of most programs.

```
------------------------- SD 5 --------------------------
!                                                       !
!      - - LENGTH FREQUENCY BAR DIAGRAM PROGRAM - -     !
!                                                       !
!                - -  PLEASE WAIT - -                   !
!                                                       !
------------------------- SD 5 --------------------------
```

While executing a program you may have forgotten the meaning of a question prompted by the program. This may happen because of the limited space on the screen which requires the questions to be expressed rather shortly. However, often the program offers an "help-option".
By choosing the help-option the screen will be cleared and some explanation will be displayed. By pressing the RETURN-key the screen will be cleared again and the display from before the execution of the help-option will reappear.

The table figures shown in SD 4 contain up to 5 digits. Most of the programs are formatted so that figures containing more than seven digits will have the first digits cut off.
This feature should be kept in mind when entering input data :

DO NOT USE MORE THAN FIVE TO SIX DIGITS

For most practical purposes in fish stock assessment this number of digits will exceed the number of significant digits.

If, for example, you have estimated a number of fish caught to be 219835763, the last 4 to 6 digits will most likely be insignificant ones. In this case you should change the unit from 1 fish to e.g. 1 million of fish, and enter as input, e.g. 219.8 instead of 219835763.

It has been attempted to format the tables so that they can cope with all reasonably scaled values one is likely to come across in fish stock assessment. (In some cases the programs allow for more than seven digits).

2.5. SOME GENERAL FEATURES OF THE DATA FILES.

The data files (e.g. containing length frequency data) are created and stored on diskettes by special data entry programs.
Most programs start by asking you about which data file you want to use as input. Thus, in many cases you cannot run a program before you have stored the input data file on diskette.
An example of a data entry program is given in the manual to the program LFINPUT.
At the end of the execution of the data entry program you are asked the question :

```
-------------------------- SD 1a --------------------------------
!                                                               !
! Do you want data to be saved on diskette (y/n) default = y    !
!                                                               !
-------------------------- SD 1a --------------------------------
```

If you answer "n" the program will prompt :

```
-------------------------- SD 1b --------------------------------
!                                                               !
!         Are you sure, default = n                             !
!                                                               !
-------------------------- SD 1b --------------------------------
```

to prevent you from losing all the data you have just entered because you entered "n" to the first question by mistake.

Suppose you have entered 'y' (or RETURN) the screen display becomes :

```
-------------------------- SD 2 ---------------------------------
!                                                               !
!      - - LENGTH FREQUENCY DATA INPUT PROGRAM - -              !
!                                                               !
!           Give disk drive (1/2) default = 2                   !
!                                                               !
-------------------------- SD 2 ---------------------------------
```

Usually the data will be stored on the diskette in disk drive no. 2 (the external disk drive), whereas the program diskette is in disk drive 1 (the built-in disk drive).
The effect of answering this question will be that the diskette whirls and soon after it displayes the "directory of the diskette"

2.5.1. DISKETTE NAMES.

The "directory" is a list of all the files stored on the diskette. It looks like SD 3

```
---------------------- SD 3 ----------------------
!                                                 !
!   /N.MARGINATUS3                                !
!                                                 !
!    NAME             TYPE  BLOCKS  MODIFIED      !
!                                                 !
!    TRAWL.M.BAY.80   TXT       12   2-JAN-81     !
!    TRAWL.M.BAY.81   TXT       14  10-FEB-82     !
!    TRAWL.M.BAY.82   TXT        3  28-APR-83     !
!    TRAWL.M.BAY.83   TXT       13   5-MAR-84     !
!    SUM.TR.M.BAY.83  TXT        5   5-MAR-84     !
!    TRAWL.M.BAY.84   TXT       15  20-JAN-85     !
!    SUM.TR.M.BAY.84  TXT        5  20-JAN-85     !
!    TRAWL.M.BAY.85   TXT       16  21-JAN-86     !
!    HOOK.M.BAY.83    TXT        2  12-DEC-83     !
!    HOOK.M.BAY.84    TXT        3   2-JAN-84     !
!    TRAWL.SULU.83    TXT        4  20-AUG-83     !
!    TRAWL.SULU.84    TXT        5  21-MAR-85     !
!    TOTAL.TR.M.BAY   TXT        1   5-MAR-86     !
!    TOTAL.HOO.M.BAY  TXT        1   5-MAR-86     !
!    TOTAL.TR.SULU    TXT        1   5-MAR-86     !
!                                                 !
!   BLOCKS FREE:   173      BLOCKS USED:  107     !
!                                                 !
!  Give name of file  ! TRAWL.M.B.84 !            !
!                                                 !
---------------------- SD 3 ----------------------
```

The name of the diskette, "N.MARGINATUS3" has been assigned to the diskette by aid of the SYSTEM UTILITY package. This is an appropriate name since the diskette contains data on the threadfinned bream Nemipterus marginatus. The suffix "3" might indicate that this is diskette no 3 with data on N. marginatus.

You are free to choose any name for the diskette you like, as long as you do it within the limitations of diskette names. These limitations are the same as those for "file names" which will be explained below.

2.5.2. FILE NAMES.

The "names" of the data files are names invented by the user. Before you save a data file you must give it a name. You are free to choose any name you like as long as you do not violate the following restrictions on file names :

The file name is composed of at most fifteen characters. "Characters" are letters A - Z and digits 0,1 - 9 and periods (.). Lower case letter are automatically converted into uppercase (thus "A" is equivalent to "a"). The first character must be a letter.

Notice that spaces are not allowed within a file name.

It is recommended to choose a file name which makes sense to you. Suppose e.g. that you have collected length frequency data on the thread finned bream, Nemipterus marginatus caught by trawl in Manila Bay during 1983. Suppose all N. marginatus data are stored on a special diskette. In that case you don't need to specify the species. You may then choose to name the file :

TRAWL.M.BAY.83

You could have named it the shortest way, say :

X

but if there are many files it may become difficult to remember which data are in the different files.

Examples of ILLEGAL FILE NAMES are :

TRAWL.MANILA.BAY.1983	(More than 15 characters)
TRAWL M B 83	(Contains spaces)
83TRAWL.M.BAY	(Starts with a digit)
TRAWL-M-B,82	(Contains the characters "-" and ",")

(If you are familiar with the PRODOS system you may benefit from using the "Path-name"-system).

Different data files on the same diskette must have different names.

WARNING : If you store a data file under a name which is already in the directory the old data file will be deleted and replaced by the new one. Thus, you must be careful not to use the same file name if you want to keep both data sets.

If you have corrected an already existing file and do not want to keep the old file containing the misprints you may delete the old version by using the same name for the corrected file.

2.5.3. DIRECTORY LIST.

The column "TYPE" in the directory (SD 3, page 13) contains abbreviations for the file type as defined by PRODOS. In this case all files are text (TXT) files. All files you create by the LFSA-package will be text files.
Other examples of PRODOS file types are : BAS (BASIC programs) and SYS (PRODOS system programs).

The column "BLOCKS" in the directory lists the number of "blocks" of disk space. A "block" consists of 512 bytes.
A 5 1/4 inch Apple II diskette can contain 280 blocks of data. As appears from the last line of the directory, 107 blocks have been used, which leaves 280 - 107 = 173 free blocks.

The rightmost column contains the most recent date when the file was modified.
The directory shown in SD 3 is created by the prodos command :

CAT

If you use the PRODOS command :

CATALOG

you will get an extended version of the directory, which e.g. shows the date when the file was created.
The dates are registered only if you enter the date when running the STARTUP diskette, as will be explained in Section 2.8.

The directory in SD 3 is produced by the PRODOS system, except for the last line, which is produced by the fisheries package.

2.5.4. LFSA DATA FILES.

The first part of any data file contains two informations :

Type of data file.

Run identification.

The "type of data file" is a short description of the data. E.g. files created by the length frquency data entry program, LFINPUT, are all of the type :

LENGTH FREQUENCY SAMPLE

This description of the data type is created by the program and usually the user does not need to care about it.

The data type will only be displayed if she/he tries to run a program using a data file which does not match the program, as shown in SD 4 :

```
------------------------ SD 4 --------------------------------
!                                                            !
!  File not expected type : LENGTH FREQUENCY SAMPLE          !
!                                                            !
!  The file type is : RESULTS OF MODAL PROGRESSION ANALYSIS  !
!                                                            !
------------------------ SD 4 --------------------------------
```

The "run-identification" is a text specified by the user.
A run-identification can be any text consisting of up to 255 characters (except for comma (,) and RETURN). 255 characters is about three full lines.
The run-identification is a text which identifies and describes the data file. The run-identification will appear in the headings to graphs and tables produced by the programs. Apart from that the run-identification is not used by the program.
As an example, we may assign a run-identification to the data file on the N. marginatus from Manila Bay. At the beginning of the execution of the data entry program for length frequencies SD 5 will appear :

```
------------------------- SD 5 ---------------------------------
!                                                              !
!          - - LENGTH FREQUENCY DATA INPUT PROGRAM - -         !
!                                                              !
!  Give run identification (max 255 characters, min 1 char.)   !
!                                        Type 'h' for help     !
!                                                              !
! ! Nemipterus marginatus caught by trawl in Manila Bay. 1983.! !
!                                                              !
------------------------- SD 5 ---------------------------------
```

The remaining part of the data file (what comes after the data type and the run-identification) contains the actual data.

How the actual data are stored on the diskette has no interest to the user.

2.5.5. HOW TO DELETE A FILE.

It may happen that you create a file by mistake. You may delete it by the PRODOS command :

```
DELETE  FN,Dx
```

where "FN" = filemane and x is the disk drive number. (But be careful when using this command).

2.6 GENERAL FEATURES OF THE MANUALS.

Each program has been given a separate manual.
A manual contains the five (or six) sections :

1. Purpose.
2. Input / input file.
3. Screen dialogue.
4. Printer output.
5. Connections to other programs.
(6. Short section on the theory (if required)).

The contents of the sections are :

1. Purpose :

Short description of what the program can do with which kind of input data and what kind of results it can produce.
Short description of the model and/or the method applied.

2. Input / input file :

Explains which type of input data are required by aid of an example or refers to other programs using the same type of input data.

3. Screen dialogue :

This section describes by an example how to run the program. The example is presented in the form of a sequence of screen displays.

The screen displays are shown in the same chronological order as they appear during an execution of the program.

The general set-up of a screen display (SD) in the manuals is shown in Figure 2.6.1.

Not all screen displays which actually occur during an execution will be shown. E.g. most programs start by showing the directory of the data diskette (cf. SD 3 on page 13). This screen display will not be shown in the examples, nor will the displays saying "PLEASE WAIT".

The same menu may occur many times during the execution of a program, but usually it will be shown only once in the manuals.

When required, suitable explanations will be inserted between the screen displays.

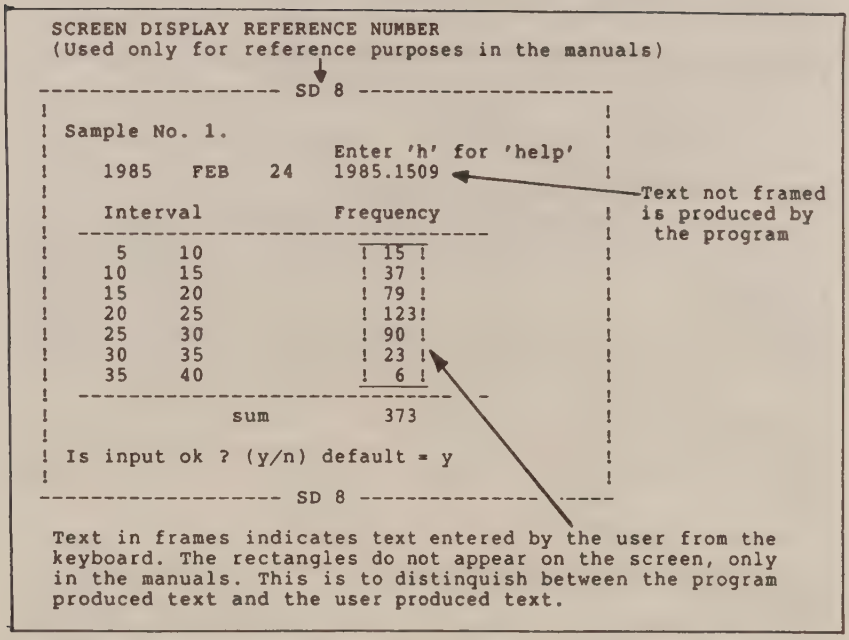

SCREEN DISPLAY REFERENCE NUMBER
(Used only for reference purposes in the manuals)
SD 8
Sample No. 1.
Enter 'h' for 'help'
1985 FEB 24 1985.1509
Text not framed is produced by the program
Interval
Frequency
5 10 15
10 15 37
15 20 79
20 25 123
25 30 90
30 35 23
35 40 6
sum 373
Is input ok ? (y/n) default = y
SD 8
Text in frames indicates text entered by the user from the keyboard. The rectangles do not appear on the screen, only in the manuals. This is to distinquish between the program produced text and the user produced text.

Figure 2.6.1. General set-up of a screen display in the manuals. The screen contains 24 lines each of which can contain 80 characters.

4. Printer output :

Almost all output on the screen can be transferred to the printer. Only such output which is expected actually to be printed will be shown in this section, i.e. what is considered the basic result of the exercise.

5. Connections to other programs :

As mentioned in section 2.3 the programs are usually not independent of each other. This section explains which program(s) you may use to continue the exercise. It also lists alternative programs by which you can analyse the data in question.

6. Short section on the theory :

Although it is assumed that the user is an experienced fish stock assessment worker, there may still be details in the method applied which cannot be considered commonly known. In that case these details are explained in this section.
Section 6 also contains references to papers or books which explain the theory behind the method. The references are given to Appendix B, which contains the full references.

2.7. THE "GRAPHICS".

Graphics is put in quotation marks because the programs do not produce what is usually considered computer graphics.

APPLE II does have the necessary software for production of high resolution graphics, but this facility has not been applied because the use of graphics occupies a major part of the available memory and because the use of APPLE graphics would make it more difficult to transfer the programs to other computers.

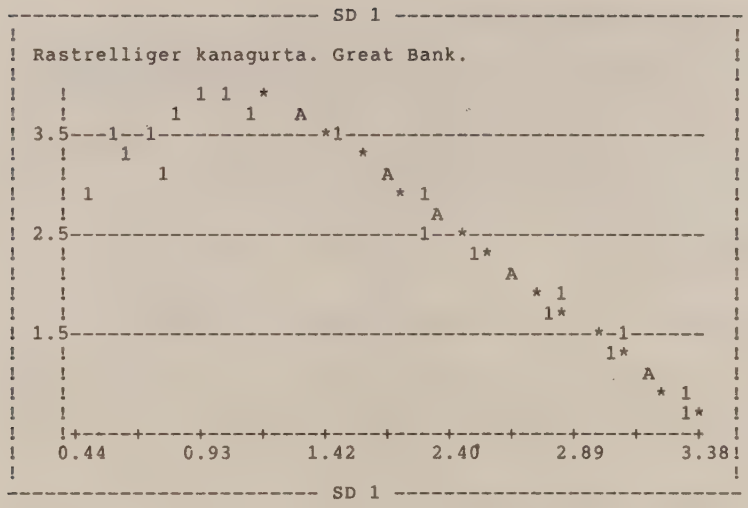
The programs do produce graphs, but they use only the PRINT command in BASIC to produce the graphs.
This implies that a graph on the screen cannot have a resolution higher than the 24 X 80 character positions available, and the graph has to be produced by aid of the characters available on the keyboard. (The LFSA package can produce larger graphs on the line printer).

The screen display shows a typical example of the type of graph produced by the programs.

The graphs produced are not considered of a quality which can go straight into a publication.

The graphs are in some cases produced to give the user a quick idea of what the plots look like. In other cases (e.g. the Bhattacharya program) they are used to assist the the user when she/he makes decisions on which options to select.

Some programs can produce graphs on the printer with a resolution of 100 X 150, which may be useful when assessing a set of data.



2.8. HOW TO GET STARTED.

The startup procedure is as follows :

1. Before you switch on the power, insert the STARTUP diskette in disk drive 1.

2. Switch on the power (Monitor and central unit and printer). The STARTUP diskette starts to whirl and in a short time you are asked to enter the date and the time. It is recommended as a routine that you do not omit this option. If you omit it your displays of directories (see SD 3, page 13, in Section 2.5) will contain the message <NO DATE> instead of the dates when you last time modified the file.

3. After you have entered the date the main menu for the package will appear on the screen, and you just follow the instructions on which program diskette to insert as will be explained in the next section.

2.9. HOW TO EXECUTE THE PROGRAMS.

There are two ways to start the execution of a program in the LFSA package :

1. Use the menu-programs.

2. Use the RUN-command.

Each program diskette contains a menu program by which you can contol the program execution of the programs on this particular diskette.
The STARTUP diskette contains the main menu program which controls the menu programs.

2.9.1. START WITH AID OF THE MENU PROGRAMS :

After insertion of the STARTUP diskette, switching on power and entering the date the STARTUP diskette will automatically activate the program "MAINMENU".
This program starts by displaying the menu :

```
------------------------ SD 1 ------------------------
!                                                     !
!  ********************************************       !
!  **                F.A.O                     **     !
!  **    PACKAGE OF LENGTH BASED FISH STOCK    **     !
!  **          ASSESSMENT PROGRAMS             **     !
!  ********************************************       !
!                                                     !
!               by P. Sparre                          !
!                                                     !
!               October 1986.                         !
!                                                     !
!                                                     !
!            M A I N   M E N U                        !
!                                                     !
!     1. Get list of menus for subpackages.           !
!                                                     !
!     2. Get list of diskette contents.               !
!                                                     !
!     3. Check contents of data files (FILEIND)       !
!                                                     !
!     Choose option, default = ! 1 !                  !
!                                                     !
------------------------ SD 1 ------------------------
```

The default option (1) brings you a menu containing the five subpackages :

```
--------------------------- SD 2 ---------------------------
!                                                          !
!      ********************************************        !
!      **                F.A.O                   **        !
!      **    PACKAGE OF LENGTH BASED FISH STOCK  **        !
!      **          ASSESSMENT PROGRAMS           **        !
!      ********************************************        !
!                                                          !
!                   LIST OF SUBPACKAGES                    !
!                                                          !
!            1 : Length frequency subpackage.              !
!                                                          !
!            2 : Age/length subpackage.                    !
!                                                          !
!            3 : Age frequency subpackage.                 !
!                                                          !
!            4 : Subpackage using parameters as input.     !
!                                                          !
!            5 : General purpose subpackage.               !
!                                                          !
!            6 : (retun to) Main Menu.                     !
!                                                          !
!            Choose subpackage  ! 1 !                      !
!                                                          !
--------------------------- SD 2 ---------------------------
```

If you select option 1 the menu program for the length frequency package will be activated and display the menu :

```
--------------------------- SD 3 ---------------------------
!                                                          !
!    ************************************************      !
!    **                  F.A.O                     **      !
!    ** PACKAGE OF FISH STOCK ASSESSMENT PROGRAMS **      !
!    **          LENGTH FREQUENCY ANALYSIS         **      !
!    ************************************************      !
!                                                          !
!    M A I N    M E N U  FOR LENGTH FREQUENCY ANALYSIS     !
!                                                          !
!  1 : DATA HANDLING (INPUT & MANIPULATION)                !
!                                                          !
!               LFINPUT    LFCONV     LFINF               !
!               LFSUM      LFMERGE    LFTABLE             !
!               LFBAR      LFMANI                         !
!                                                          !
!  2 : DATA PROCESSING (PARAMETER ESTIMATION)              !
!                                                          !
!               BHATTAC    MODALGR    MODALPR             !
!               GHBIRTH    CCURVE     BHZWET              !
!               JONZAL     LCOHOR                         !
!                                                          !
!  3 : Change dimension of programs (DIMENSION)            !
!                                                          !
!    Choose option ! 1 !                                   !
!                                                          !
--------------------------- SD 3 ---------------------------
```

The abbreviations (e.g. "LFINPUT" and "LFCONV") are program names.

Suppose you want to enter raw data, then you select option 1 and the following menu appears on the screen :

```
--------------------------- SD 4 -------------------------------
!                                                               !
!    ********************************************             !
!    **                  F.A.O                     **           !
!    ** PACKAGE OF FISH STOCK ASSESSMENT PROGRAMS **           !
!    **         LENGTH FREQUENCY ANALYSIS          **           !
!    ********************************************             !
!                                                               !
!              DATA HANDLING  M E N U                           !
!                                                               !
!  1 : ENTER NEW FILE OR CHANGE OLD FILE (Ordinary lgt. frq.)   !
!                                        LFINPUT                !
!  2 : ENTER NEW FILE OR CHANGE OLD FILE (Data which require    !
!      a conversion. E.g. fork length to total length)          !
!                                        LFCONV                 !
!  3 : MANIPULATION OF EXISTING FILES.   LFMANI,LFMERG,LFCONV   !
!  4 : DISPLAY OF BAR DIAGRAMS           LFBAR                  !
!  5 : DISPLAY OF TABLES                 LFTABLE                !
!  6 : ENTER ADDITIONAL DATA             LFINF                  !
!  7 : ADD SAMPLES                       LFSUM                  !
!  8 : QUIT (Return to main menu)                               !
!                                                               !
!    Choose option ! 1 !                                        !
!                                                               !
--------------------------- SD 4 -------------------------------
```

The next step is to select option 1 which then tells you to insert program diskette no. 1 :

```
--------------------------- SD 5 -------------------------------
!                                                               !
!    ********************************************             !
!    **                  F.A.O                     **           !
!    ** PACKAGE OF FISH STOCK ASSESSMENT PROGRAMS **           !
!    **         LENGTH FREQUENCY ANALYSIS          **           !
!    ********************************************             !
!                                                               !
!   INSERT PROGRAM DISKETTE NO. 1 IN DISK DRIVE NO. 1           !
!                                                               !
!            AND THEN PRESS THE RETURN-KEY.                     !
!                                                               !
--------------------------- SD 5 -------------------------------
```

Then, eventually, the program you want to run will be activated.

2.9.2. START BY USING THE RUN-COMMAND.

Alternatively, you may stop the main menu program by CONTROL-C when SD 1 appears. Then you insert program diskette no. 1 and type the command :

RUN LFINPUT (or RUN LFINPUT,D1)

The suffix ",D1" tells the computer that the program is in disk drive no. 1. The suffix is optional. If it is omitted the computer will assume the disk drive used the last time a disk drive was activated. (Thus in this particular case ",D1" is not required).
The RUN command will then load the program LFINPUT and start the execution.
This technique requires that you know the name of the program (LFINPUT) and that you know that this program is stored on program diskette no. 1.
To enable you to apply the RUN command a complete list of the contents of all programs is given in Appendix A. You may also obtain this list on the screen by choosing option 2 from the menu in SD 1, the main menu.

If you abort the execution by CONTROL-C and change program diskette you can always start the diskette by :

RUN MENU,D1

This command will activate the menu program for that diskette. You may also go straight to the program you want as explained above.

2.9.3. EXECUTION OF PROGRAMS.

Once the program has been activated it may start in two different ways depending on which type of program it is :

1. Display a menu (This applies e.g. to data entry programs)

2. Ask you for the name of the data file (This applies to most programs which are not data entry programs)

In the case of option 2, the program starts e.g. as follows :

```
---------------------- SD 1 ----------------------------
!                                                      !
!     - - MERGING OF LENGTH FREQUENCY FILES - -        !
!                                                      !
!     Give disk drive (1/2) default = 2  ! RETURN !    !
!                                                      !
---------------------- SD 1 ----------------------------
```

Next screen display is the directory of the data diskette (like SD 3 in Section 2.5, page 13).
The directory may contain more than 24 lines, in which case the first lines will disappear off the top of the screen. You may in this case use the CONTROL-S option to suspend the listing before the first lines disappear.
Alternatively you may have the directory printed on the line-printer. The program FILEIND offers you that option. You may also get a print by the three consecutive commands :

Command :	Explanation :
PR#1	(directs output to line printer)
CAT,Dx (or CATALOG,Dx)	(displays the directory. The typed command is not not visible on screen, because of PR#1) x = disk drive number.
PR#0	(directs output to screen, still not visible on screen, because of PR#1)

After the command PR#0 you will again see what you type on the screen.

Then you enter the name of the data file you want to use as input (see last line on SD 3 in section 2.5) and the actual processing can start.

The first thing to happen usually is that the program displays a message on the content of the selected file. In the case of a program from the LF (Length Frequency) subpackage this message consists of the run-identification and a list of dates pertaining to the time series as shown in SD 2.

SD 2

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

The time series contains the samples :

s	year	month	day	time
1	1985	APR	4	1985.25753
2	1985	JUL	7	1985.51507
3	1985	OCT	15	1985.78904
4	1986	JAN	10	1986.02740

SD 2

The column "time" contains the dates converted into decimal numbers (as explained in the manual to the program LFINPUT).

2.10. THE PROGRAM "FILEIND".

Having used the LFSA package for a while you may have produced a large number of data diskettes.

The program FILEIND enables you to check the content of a data diskette.

You may also use FILEIND to produce tables of diskette contents. FILEIND is an abbreviation for "File Identification".

The program produces an extended directory (cf. Section 2.5). It displays the information you can obtain by the PRODOS command "CATALOG" together with the data type as defined in the LFSA package and the run identification for each data file.

The only input you have to provide is number of the disk drive.

You may start FILEIND by choosing option 3 in the main menu (SD 1, page 21 in Section 2.9).

Using the example from SD 3 (page 13, Section 2.5.1) the dialogue becomes :

```
---------------------- SD 1 ----------------------------
!                                                      !
!         - - FILE IDENTIFICATION PROGRAM  - -         !
!                                                      !
!     Give disk drive (1/2) default = 2  ! RETURN !    !
!                                                      !
---------------------- SD 1 ----------------------------
```

The effect is that the directory is displayed (as shown in SD 3 in Section 2.5), followed by the prompt :

```
--------------------------- SD 2 -------------------------------
!                                                              !
! Do you want the directory printed default = n  ! RETURN !   !
!                                                              !
--------------------------- SD 2 -------------------------------
```

If you answer 'y' to this prompt the directory you just saw on the screen (not the extended one) will be printed.

We use as example the data diskette with the directory shown in SD 3 in Section 2.5.1. The next screen displays will be the extended directory shown in portions. Here we show only the first portion :

```
------------------------------ SD 3 -------------------------------
! /N.MARGINATUS3                                                   !
!                                                                  !
!  NAME           TYPE  BLOCKS  MODIFIED  CREATED       ENDFILE  !
!                                                                  !
!  ---------------------------------------------------------------!
!  TRAWL.M.BAY.80  TXT      12   2-JAN-81 12-DEC-80 16:20  533   !
!  LENGTH FREQUENCY SAMPLE                                         !
!  Nemipterus marginatus. Manila Bay 1980. Trawl Survey.           !
!  ---------------------------------------------------------------!
!  TRAWL.M.BAY.81  TXT      14  10-FEB-82  1-JAN-82 09:38 1772   !
!  LENGTH FREQUENCY SAMPLE                                         !
!  Nemipterus marginatus. Manila Bay 1981. Trawl Survey.           !
!  ---------------------------------------------------------------!
!  TRAWL.M.BAY.82  TXT       3  28-APR-83 16-JUL-82 11:01 1456   !
!  LENGTH FREQUENCY SAMPLE                                         !
!  Nemipterus marginatus. Manila Bay 1982. Trawl Survey.           !
!  ---------------------------------------------------------------!
!  TRAWL.M.BAY.83  TXT      13   5-MAR-84 23-AUG-83 07:52 2779   !
!  LENGTH FREQUENCY SAMPLE                                         !
!  Nemipterus marginatus. Manila Bay 1984. Trawl Survey.           !
!  ---------------------------------------------------------------!
!  !RETURN!                                                        !
------------------------------ SD 3 -------------------------------
```

The first line for each file is the line produced by PRODOS, the second line shows the LFSA data type and the third line is the run identification.
The first line contains two more columns compared to SD 3 in Section 2.5, namely :

CREATED : The date and time the file was created.

ENDFILE : The number of bytes used by the file.
If this figure is zero the file is (usually) a file you created by a mistake, e.g. by misspelling a file name. You can delete such a file by the DELETE command as explained in Section 2.5.5.

Having scrolled through the extended directory you get the menu

```
---------------------- SD 4 ---------------------------
!                                                     !
!        - - FILE IDENTIFICATION PROGRAM  - -         !
!                                                     !
!          1 : Print table on printer                 !
!          2 : Inspect more diskettes                 !
!          3 : Quit (return to main menu)             !
!                                                     !
!     Choose option  ! 1 !                            !
!                                                     !
---------------------- SD 4 ---------------------------
```

2.11. GLOSSARY.

BASIC : Short for Beginners All-purpose Symbolic Instruction Code The most popular computer language for micro computers. APPLE II uses the BASIC dialect APPLESOFT BASIC.

Block : Disk space unit (512 bytes). A diskette contains 280 blocks.

CAT : PRODOS command. Produces a list of diskette contents (the directory).

CATALOG : As "CAT" but with more details.

Central unit : The part of the computer system which contains the microprocessor and the memory. In the case of APPLE II it is in the device with the keyboard.

CONTROL-C : BASIC command. Aborts the execution of a running program. (Press the C-key while holding down the CONTROL-key)

CONTROL-S : BASIC command. Suspends display of output on the screen. (Press the S-key while holding down the CONTROL-key)

Data file : A collection of data (raw or processed) stored on a disk. In the terminology of PRODOS a data file is a "text file" (TXT-file).

DELETE FN,Dx : PRODOS command. Deletes the file with name "FN" on disk drive x.

Directory : List of contents of a diskette (See "CAT").

Disk drive : A device that loads information from disks into the memory of the computer and save information from the memory of the computer onto the disk.

Disk operating system : A software system for the computer that enables it to control and communicate with one or more disk drives (The LFSA package uses PRODOS).

Diskette : A circle of flexible plastic coated with iron oxide (the same sort of thing they make casette tape out of). Diskettes are used to store information on.

Display : (1) Information exhibited visually, especially on the screen. (2) To exibit information visually. (3) A display device.

Edit : To change or modify, for example, to insert, remove, replace or move text in a document.

Field : A part of a record.

File : A collection of information stored on a disk.

File name : A name (specified by the user) for a file.
(for restrictions on file names, see Section 2.5).

Floppy disk drive : See "disk drive".

LFSA : Short for "Length based Fish Stock Assessment".

Graphics : Information presented in the form of pictures (e.g. graphs) on the screen or on the printer.

Hardware : The physical (electronical or mechanical) devices (Printer, disk drive etc.)

K : 1 kilo byte = 1024 bytes (one character occupies 1 byte).

Menu : A list of options displayed on the screen from which the user can select.

Menu-program : A program by which other programs can be selected loaded from diskettes and the execution can be started.

Microcomputer : A computer, such as APPLE II, whose processor is a microprocessor.

Microprocessor : A processor is the "brain" of a computer.
A microprocessor is a computer processor which is contained in a single integrated circuit.
The APPLE II has a 6502 eight-bit microprocessor.

LF : Short for "Length Frequency"

Monitor : Looks like a TV. It displays instructions from the the programs to you and shows what you have typed into the memory.

Package : Suite of (computer) programs.

PRODOS : Short for "PROfessional Disk Operating System". A software system for APPLE II that enables it to control and communicate with the disk drives.

Program : (Computer program). Instructions that tell the computer what to do.

PR#0 and PR#1 : PRODOS commands :
PR#1 : Sends output to printer (changing from screen)
PR#0 : Sends output to screen (changing from printer)

RAM : Temporary memory in the computer. RAM stores programs and data for the microprocessor.

Record : A unit part of a file. E.g. a length frequency sample in a file containing a time series of length frequency samples.

RUN-command : BASIC command. Using "RUN" you start the execution of a program which is in the computer. Using "RUN PN,Dx" you load the program named "PN" from disk drive x and and start the execution.

RUN-identification : A text string attached to each file describing the content of the file (expressed in plain English of the users choice). The run identification appears in the headings on all output tables and graphs.

SD x : Short for "Screen Display no. x".

Software : Computer program or systems (like PRODOS and the package of fish stock assessment programs).

START-UP diskette : A diskette containing the systems PRODOS and BASIC. Must be loaded into the computer before the LFSA-package can be run.

STARTUP-program : A program on the start-up diskette which starts automatically when the power is switched on (if the start-up diskette is in the disk drive).

SYSTEM ULTILITIES : A software package that gives you control over the information you save on disks. (E.g. let you copy diskettes and individual files).

Text file : A collection of data (raw or processed) stored on a disk (a PRODOS TXT-file). Also called a data file in the present manual.

TYPE OF FILE AS DEFINED BY THE LFSA-PACKAGE : This is a label attached to each data file produced by the LFSA package. The type declaration is made by the LFSA programs, and is used by the LFSA programs to check whether input data match the program.

TYPE OF FILE AS DEFINED BY PRODOS : This is the type given in the directory list. (See Section 2.5).

80-columns text card : A circuit board used in APPLE IIe to double the number of characters from 40 to 80 across the screen. This capacity is built into the APPLE IIc.

3. LENGTH FREQUENCY ANALYSIS (LF) SUB-PACKAGE.

3.1. INTRODUCTION.

Below follows a list of the programs contained in the LF-subpackage together with a very short description of the programs. Figure 3.1.1. shows the possible flows of data between the programs.

LF.1. MENU : LF main menu.
The menu program by which you load the programs from the program diskettes (no manual for this program).

LF.2. LFINPUT : LF data entry program.
This program is used to enter raw data, i.e. time series of length frequency samples. LFINPUT also offers options for editing and amending.

The data are: 1. A user specified text to identify the file (run identification).
2. Date of sampling.
3. Numbers by length group.

The samples can be entered in any order as LFINPUT sorts the samples in chronological order.
New samples can be amended and existing samples can be modified or deleted.

LF.3. LFINF : LF "additional-information-on-lgt.-frq." program.
This program offers an optional extension to LFINPUT. You may (if you wish) attach "additional information" to each length frequency sample, such as position, depth gear type, sample weight , etc.
Existing files can be edited.

LF.4. LFTABLE : LF table program.
Produces tables of length frequency samples.

LF.5. LFBAR : LF bar diagram program.
LFBAR produces bar diagrams of length frequencies.

LF.6. LFSUM : LF data summing program.
LFSUM can produce a weighted sum of length frequencies. E.g. if you entered CPUE data by LFINF the program LFSUM can calculate the sum of frequecies weighted by CPUE.
LFSUM is expected to be used for the primary processing of raw data taken directly from the sampling schemes and logbooks.
It can be used to produce the tables in technical reports, and for saving of raw data.

LF.7. LFCONV : LF data conversion program.
This program is an extended version of LFINPUT. In addition to the options of LFSUM you can use LFCONV to e.g. convert fork lengths into total lengths. LFCONV offers a number of different conversions of length frequencies. LFCONV is not intended for use on a routine basis, it is mainly planned for handling of data which happened not to be in the planned format.

LF.8. LFMANI : LF data manipulation program.
LFMANI offers a number of different manipulations of data , e.g. adjustment for mesh selection, change of length class interval. Change lower limit of first length group. To run the catch curve analysis programs (CCURVE, BHZWET, JONZAL and LCOHOR) you must start summing the frequencies by aid of LFMANI.

LF.9. LFMERGE : LF file merging program.
Merges length frequency files so that they are sorted in chronological order.

LF.10. BHATTAC : Bhattacharya analysis program.
Resolves a length frequency sample into a number of normally distributed components (cohorts).
The user must monitor the estimation process and take a number of decisions during the processing.

LF.11. MODALGR : Graph and table program for BHATTAC.
Produces tables and graphs of the results from BHATTAC.

LF.12. MODALPR : Modal progression analysis.
MODALPR is the continuation of BHATTAC.
Based on the graphs produced by MODALGR the user connects the modes to produce modal progressions. By aid of the Gulland & Holt plot MODALPR then estimates Loo and K. The birthday of each cohort is then estimated from the von Bertalanffy plot.

LF.13. GHBIRTH : Gulland & Holt plot - birthday analysis
GHBIRTH is the continuation of MODALPR. It enables you to make an estimate of birthday from the pooled data from all cohorts, and thereby give estimates of the approximate absolute ages.
It also produces a graph of the Gulland and Holt analysis of MODALPR.

LF.14. CCURVE : Length converted catch curve analysis and selection ogive analysis.
Input to CCURVE must be the sum of length frequencies over a longer period (preferably not less than one year). The summed length frequencies are produced by the program LFMANI. The same thing applies to the programs BHZWET, JONZAL and LCOHOR.
The sample must be representative of the population.
CCURVE also requires as input Loo and K.
Output are Z (total mortality) and the resultant selection ogive (described by the logistic curve).

LF.15. BHZWET : Beverton & Holt's Z-equation and Wetherall et. al. analysis.
Requires the same lgt. frq. input data as CCURVE.
The sample must be representative of the population.
This program can perform two different estimation procedures :

1. Estimates Z from Beverton and Holt's formula :

$$Z = K*(Loo-L)/(L-L')$$

where L = mean length of fish longer than L' when Loo and K are given as input.

2. Estimation of Loo and Z/K by the modified Wetherall et. al. method, i.e. the regression

$$L - L' = a + bL'$$

where L = mean length of fish longer than L', a and b are regression coefficients and
$Loo = -a/b$, $Z/K = -(1-b)/b$

LF.16. JONZAL : Jones & van Zalinge analysis.
Requires the same lgt. frq. input data as CCURVE.
The sample must be representative of the population.
Estimates Z by the Jones and van Zalinge method (the cumulated catch curve).

LF.17. LCOHOR : Jones' length converted cohort analysis.
Requires the same lgt. frq. input data as CCURVE, but the sample must represent the total landing.
If M, natural mortality, Loo and K are known LCOHOR estimates the fishing mortality, F, by length group and the population size by length group.

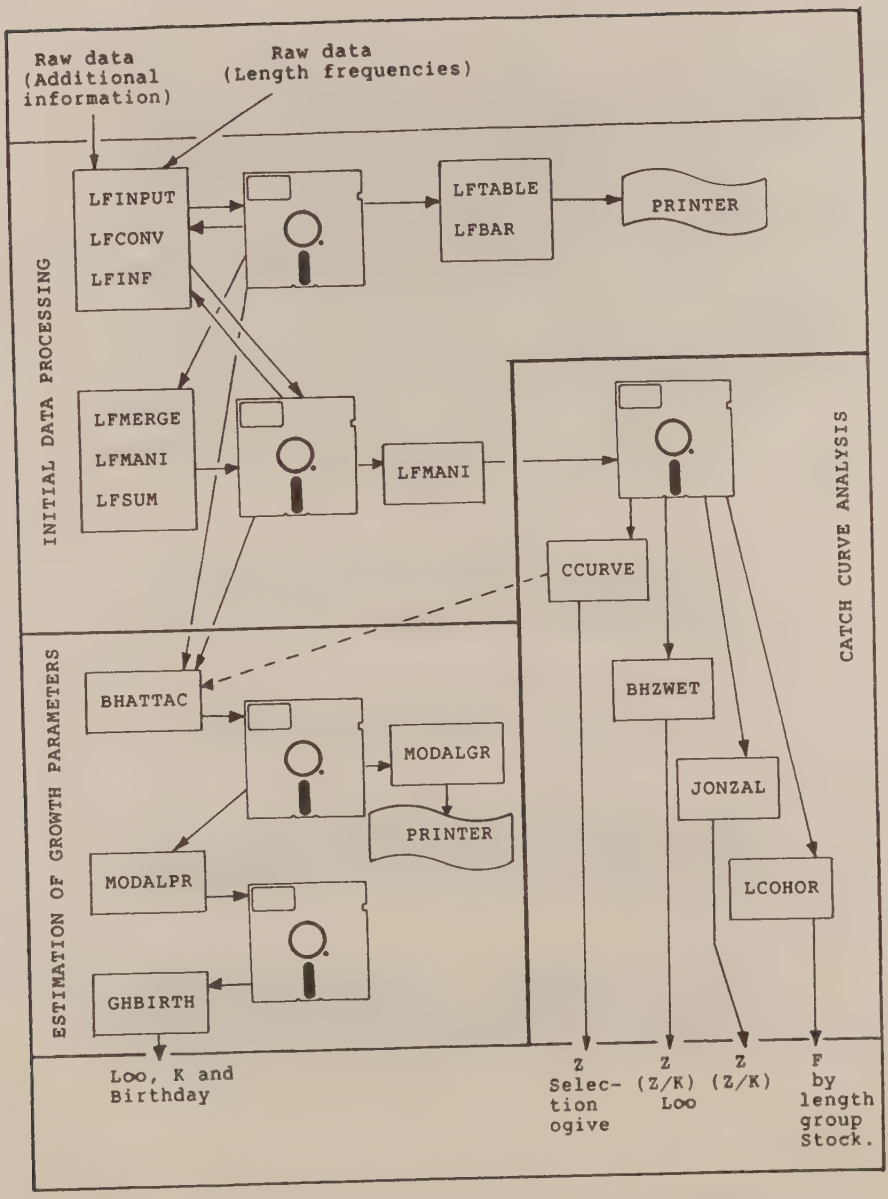


Figure 3.1.1. Data flows in the Length Frequency subpackage

DIMENSION OF LF-PROGRAMS :

All programs in the LF subpackage are dimensioned to accept a maximum number of 20 samples and a maximum number of 50 frequencies in each sample.
Thus, the maximum total number of frequencies is :

20 * 50 = 1000

If you try to enter a file the dimension of which exceeds the dimension of the program you will get a message like

```
------------------------------ SD 1 ------------------------------
!                                                                 !
! Maximum number of length groups exceeded                        !
! Please terminate the sample by 'e' instead of 'frequency'       !
!                                                                 !
------------------------------ SD 1 ------------------------------
```

It is, however, possible to change the dimension by running the program "DIMENSION" which changes the dimension of all programs on one diskette. Notice that DIMENSION must be executed for each diskette separately.

By "RUN DIMENSION,D1" the dialogues becomes :

```
------------------------------ SD 2 ------------------------------
!                                                                 !
!       DIMENSIONING OF LENGTH FREQUENCY PROGRAMS                 !
!                                                                 !
!  Current dimensions are :                                       !
!                                                                 !
!  Max number of samples       20                                 !
!  Max number of frequencies   50                                 !
!                                        'return' : old value kept !
!                                                                 !
!  Give new max number of samples     ! 40 !                      !
!  Give new max number of frequencies ! 25 !                      !
!                        (samples X frequencies) = 1000           !
!                                                                 !
!  Is input ok ?  !RETURN!                                        !
!                                                                 !
------------------------------ SD 2 ------------------------------
```

It is recommended not to let the product (samples X frequencies) exceed 1500, because this may in some cases create problems because of the limited capacity of APPLE II.

With the standard dimension (20X50) no problems have been encoutered so far.

If you dimension too high, this may cause the error messages :

"NO BUFFERS AVAILABLE" or "OUT OF MEMORY"

In case you try to retrieve a file the dimension of which exceeds the current dimension of the program you will get the error message :

"BAD SUBSCRIPT"

It is recommended to use DIMENSION only when it is really required. If, say, all your samples contains less than 30 frequencies and your time series contains up to 30 samples there may be a good reason for changing the dimensions.

3.2. LFINPUT.

3.2.1. PURPOSE .

LFINPUT is used to enter and edit files containing time series of length frequency samples.

A length frequency file is a time series of length frequency samples. A file contains the information (which will be further explained in the following sections) :

F.1 : Run identification.
F.2 : Length group specification :
Lower limit of first length group.
Length interval size.
F.3 : A number of records, each record being a length frequency sample.

A record (a length frequency sample) contains the information :

R.1. Date of sample.
R.2. A number of frequencies, starting with the first length as defined by F.2.
R.3. "Additional data". It is optional to enter additional data. These are information on depth, position etc., as will be explained in the manual to LFINF.

3.2.2. INPUT/INPUT FILE.

An example of raw data is shown in Table 3.2.2.1. The example deals with five samples collected during five days. You may imagine these to be obtained during a five day trawl research survey on "Great Bank" April 1985 for investigation of Rastrelliger neglectus.

Input to LFINPUT is either entered only from the keyboard or both from keyboard and disk. If you start from scratch creating a new file all input are entered from the keyboard. But you may as well start by retrieving a file created earlier by LFINPUT for editing or for adding of new samples.

The type of file is

LENGTH FREQUENCY SAMPLE

This type of data file is created from scratch either by the program LFINPUT or by the program LFCONV

April 1985

Length cm	2/4	3/4	4/4	5/4	6/4
6 - 8	25	18	24	19	23
8 - 10	120	135	125	128	130
10 - 12	19	21	15	28	22
12 - 14	100	70	85	86	81
14 - 16	222	271	301	283	278
16 - 18	171	158	243	208	262
18 - 20	138	140	109	152	153
20 - 22	100	88	117	105	117
22 - 24	49	67	56	58	49
24 - 26	15	24	17	34	22
26 - 28	9	4	5	7	6
28 - 30	0	1	0	1	1
Total	968	997	1097	1109	1144

Table 3.2.2.1. Example of raw length frequency data.

3.2.3. SCREEN DIALOGUE.

3.2.3.1. STARTING FROM SCRATCH .

The opening screen display of LFINPUT is shown in SD 1.

The first example deals with how to enter a file from scratch. In that case you select option 1 in SD 1, which produces SD 2.

The first data to enter are the run-identification (cf. Section 2.5) and the length group specification as shown in SD 2 (Compare Table 3.2.2.1). By SD 2 you have defined the length groups for all samples in the file, i.e. 2 cm groups, the first group being 6 - 8 cm.

In SD 3 the date of a sample is entered (in this example the first sample in Table 3.2.2.1). You may either enter the year as "1985" or as "85". The program will not accept non existent dates and if you enter such a date the program responds by repeating the prompt.

```
------------------------------ SD 1 -------------------------------
!                                                                  !
!        - - LENGTH FREQUENCY DATA INPUT PROGRAM - -               !
!                                                                  !
!           1 : Enter new file.                                    !
!                                                                  !
!           2 : Correct or amend old file stored on disk.          !
!                                                                  !
!           3 : Enter additional data        (LFINF)               !
!                                                                  !
!           4 : Print table.                 (LFTABLE)             !
!                                                                  !
!           5 : Print bar diagram.           (LFBAR)               !
!                                                                  !
!           6 : Quit (return to main menu).                        !
!                                                                  !
!           7 : Help.                                              !
!                                                                  !
!               (1 or 2 must be executed before 3, 4 and 5)        !
!                                                                  !
!           Choose option  ! 1 !                                   !
!                                                                  !
------------------------------ SD 1 -------------------------------

------------------------------ SD 2 -------------------------------
!                                                                  !
!          - - LENGTH FREQUENCY DATA INPUT PROGRAM - -             !
!                                                                  !
! Give run identification (max 255 characters, min 1 chr.)         !
!                    Enter 'h' for 'help'                          !
!                                                                  !
!!Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank !!
!                                                                  !
!    Give length interval size                 ! 2 !               !
!    Give lower limit of first length group    ! 6 !               !
!                                                                  !
!    Is input ok ? (y/n) default = y  !RETURN!                     !
!                                                                  !
------------------------------ SD 2 -------------------------------

------------------------------ SD 3 -------------------------------
!                                                                  !
!          - - LENGTH FREQUENCY DATA INPUT PROGRAM - -             !
!                                                                  !
!                    Enter 'h' for 'help'                          !
!                                                                  !
!    Give year of sample             ! 85 !                        !
!    Give month of sample            !  4 !                        !
!    Give day of sample              !  2 !                        !
!                                                                  !
!    Sample time :  1985.25205                                     !
!                                                                  !
!    Is input ok ? (y/n) default = y  !RETURN!                     !
!                                                                  !
------------------------------ SD 3 -------------------------------
```

The "sample time" is the date converted into a decimal number :

sample time = year + (number of day in the year)/365

This figure is used later in the processing of the length frequencies.
In the present example the earliest sample in the time series is entered as no. 1. However, you can enter the samples in any order you like as the program will sort them into chronological order.

```
-------------------------- SD 4 -----------------------------
!  Sample no. 1.                                             !
!                                        Enter 'h' for 'help' !
!       1985   APR   2    1985.25205                         !
!                                                            !
!      Length group              frequency                   !
!     ---------------------------------------                !
!         6     8                 ! 25   !                  !
!         8    10                 ! 120  !                  !
!        10    12                 ! 19   !                  !
!        12    14                 ! 1000 !                  !
!        14    16                 ! 222  !                  !
!        16    18                 ! 171  !                  !
!        18    20                 ! 138  !                  !
!        20    22                 ! 100  !                  !
!        22    24                 ! 49   !                  !
!        24    26                 ! 15   !                  !
!        26    28                 ! 9    !                  !
!        28    30                 ! e    !                  !
!     ---------------------------------------                !
!                        Sum        1868                     !
!                                                            !
!     Is input ok ? (y/n) default = y  ! n !                 !
!                                                            !
-------------------------- SD 4 -----------------------------
```

In SD 4 you enter the frequencies starting with length group 6-8 cm. The letter e used for the last frequency 28-30 cm is a terminator and will be explained later.
Notice that the frequency for interval 12-14 cm is wrong (compare Table 3.2.2.1). Consequently the sum calculated by the program, 1868 deviates from the sum in Table 3.2.2.1.
If you mistype a number you answer 'n' to the last question in SD 4. Hereby you get the opportunity to edit the data entered as shown in SD 5.
You scroll through the data by using the RETURN-key. Whenever you press the RETURN-key a new line is displayed. When you reach the misprinted figure you correct it by entering the correct figure.
You may repeat this procedure as many times as you like. The program offers you a number of different edit commands which will be discussed in connection with SD 9.

```
--------------------------- SD 5 -----------------------------
!                                                            !
!  Sample no. 1.                                             !
!                                        Enter 'h' for 'help'!
!       1985   APR   2    1985.25205                         !
!                                                            !
!      Length group              frequency                   !
!    ------------------------------------------------------  !
!         6      8                  25      ?  ! RETURN !    !
!         8     10                  120     ?  ! RETURN !    !
!        10     12                  19      ?  ! RETURN !    !
!        12     14                  1000    ?  ! 100    !    !
!        14     16                  222     ?  ! RETURN !    !
!        16     18                  171     ?  ! RETURN !    !
!        18     20                  138     ?  ! RETURN !    !
!        20     22                  100     ?  ! RETURN !    !
!        22     24                  49      ?  ! RETURN !    !
!        24     26                  15      ?  ! RETURN !    !
!        26     28                  9       ?  ! RETURN !    !
!    ------------------------------------------------------  !
!                        Sum         968                     !
!                                                            !
!    Is input ok ? (y/n) default = y  ! RETURN !             !
!                                                            !
--------------------------- SD 5 -----------------------------
```

With SD 5 the first sample has been succesfully entered. In SD 6 the date for the next sample is entered.

```
--------------------------- SD 6 -----------------------------
!                                                            !
!      - - LENGTH FREQUENCY DATA INPUT PROGRAM - -           !
!                                                            !
!               Enter 'h' for 'help'                         !
!                                                            !
!    Give year of sample          ! 85 !                     !
!    Give month of sample         !  4 !                     !
!    Give day of sample           !  3 !                     !
!                                                            !
!    Sample time :  1985.25479                               !
!                                                            !
!    Is input ok ? (y/n) default = y  !RETURN!               !
!                                                            !
--------------------------- SD 6 -----------------------------
```

SD 6 is equivalent to SD 3. The next screen display shows you which samples you now have in the file and which one you are about to enter.

```
---------------------------- SD 7 -----------------------------
!                                                             !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank !
!                                                             !
!  The time series now contains the samples :                 !
!                                                             !
!   s    year     month     day       time                   !
!  ------------------------------------------                 !
!   1    1985      APR       2      1985.25205                !
!   2    1985      APR       3      1985.25479                !
!                      You are now going to enter sample no. 2 !
!                                                             !
!  !RETURN!                                                   !
!                                                             !
---------------------------- SD 7 -----------------------------
```

SD 8 is equivalent to SD 4. The only difference is that in SD 8 we forgot a frequency whereas in SD 4 a frequency was mistyped (compare Table 3.2.2.1)

```
--------------------------- SD 8 ------------------------------
!                                                             !
!  Sample no. 2.                                              !
!                                          Enter 'h' for 'help' !
!       1985   APR   3    1985.25479                          !
!                                                             !
!      Length group              frequency                    !
!     ---------------------------------------                 !
!        6     8                  ! 18   !                    !
!        8    10                  ! 135  !                    !
!       10    12                  ! 21   !                    !
!       12    14                  ! 70   !                    !
!       14    16                  ! 271  !                    !
!       16    18                  ! 158  !                    !
!       18    20                  ! 88   !  <----             !
!       20    22                  ! 67   !                    !
!       22    24                  ! 24   !                    !
!       24    26                  !  4   !                    !
!       26    28                  !  1   !                    !
!       28    30                  ! e    !                    !
!     ---------------------------------------                 !
!                        Sum        857                       !
!                                                             !
!     Is input ok ? (y/n) default = y  ! n !                  !
!                                                             !
--------------------------- SD 8 ------------------------------
```

SD 9 and SD 10 show you how to insert a missing value.

```
------------------------- SD 9 -----------------------------
!  Sample no. 2.                                            !
!                                      Enter 'h' for 'help'  !
!       1985   APR   3    1985.25479                        !
!                                                          !
!      Length group              frequency                 !
!     ------------------------------------------------     !
!         6      8                 18     ? ! RETURN !     !
!         8     10                135     ? ! RETURN !     !
!        10     12                 21     ? ! RETURN !     !
!        12     14                 70     ? ! RETURN !     !
!        14     16                271     ? ! RETURN !     !
!        16     18                158     ? ! h      !     !
!                                                          !
------------------------- SD 9 -----------------------------
```

You scroll through the the frequencies until the frequency before the missing one. In case you don't know (or have forgotten) how to insert a missing value you can ask for help by 'h'.

```
------------------------- SD 10 ----------------------------
!                                                          !
!  TO CORRECT SAMPLES YOU HAVE THE OPTIONS :               !
!                                                          !
!  RETURN : Continue to next observation leaving           !
!           the current observation unchanged              !
!                                                          !
!  <numeric value> : Replaces the current observation      !
!           by <numeric value>                             !
!                                                          !
!  d       : Delete current observation                    !
!                                                          !
!  i       : Insert new obsevation before current observation!
!                                                          !
!  a       : Amend new obsevation after current observation !
!                                                          !
!  e       : Skip, i.e. leave the rest of the sample unchan- !
!           ged and continue with next sample              !
!                                                          !
! delete sample : delete entire sample (this command       !
!           cannot be abbreviated)                         !
!                                                          !
! (To amend more than 1 freq. to the end, start by 'a' and !
! then continue with 'i' for the last 0-freq. Stop by 'e') !
!                                                          !
!  !RETURN!                                                !
------------------------- SD 10 ----------------------------
```

Sd 10 gives you the edit commands available. After RETURN in SD 10, SD 9 reappears on the screen and where 'h' is on SD 9 you enter 'i' which has the effect that all frequencies (observations) after length group 16-18 cm are moved one position forward. Then you can enter the missing value : 140 (cf. Table 3.2.2.1).

Now, suppose that after entering the sample of 3. April you wish to enter one of 5. April and then one of 4. April. After entering the date (4. April 1985) you get the message in SD 11.

```
---------------------------- SD 11 -----------------------------
!                                                              !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank !
!                                                              !
!  The time series now contain the samples :                   !
!                                                              !
!   s    year    month    day      time                        !
!  ------------------------------------                        !
!   1    1985     APR      2     1985.25205                   !
!   2    1985     APR      3     1985.25479                   !
!   3    1985     APR      4     1985.25753                   !
!                      You are now going to enter sample no. 3 !
!   4    1985     APR      5     1985.26027                   !
!                                                              !
!  !RETURN!                                                    !
---------------------------- SD 11 -----------------------------
```

Notice that the samples are ordered in chronological order.

Now, suppose that all five samples have been entered and you want to store them in the file on diskette. You terminate the time series (the file) by entering 'e' instead of 'year of sample' as shown in SD 12 :

```
---------------------------- SD 12 -----------------------------
!                                                              !
!        - - LENGTH FREQUENCY DATA INPUT PROGRAM - -           !
!                                                              !
!                    Enter 'h' for 'help'                      !
!                                                              !
!   Give year of sample            ! e !                      !
!                                                              !
---------------------------- SD 12 -----------------------------
```

An then follows :

```
---------------------------- SD 13 -----------------------------
!                                                              !
! Do you want data to be saved on diskette (y/n) default = y   !
!                                                 ! RETURN !!  !
---------------------------- SD 13 -----------------------------

---------------------------- SD 14 -----------------------------
!                                                              !
!          - - LENGTH FREQUENCY DATA INPUT PROGRAM - -         !
!                                                              !
!          Give disk drive (1/2) default = 2  ! RETURN !       !
!                                                              !
---------------------------- SD 14 -----------------------------
```

Next screen display is the directory of the data diskette (cf. SD 3 in Section 2.5) followed by the prompt :

```
------------------------------ SD 15 ------------------------------
!                                                                  !
! Give name of file ('p' if you want the directory printed)        !
!                                                                  !
!                                                ! R.kanagurta.5 ! !
------------------------------ SD 15 ------------------------------
```

This causes the file to be stored on the data diskette under the name "R.kanagurta.5".

If you answer 'y' (or 'RETURN') to the question in next screen display (SD 16) a new program, LFINF, will be loaded into the computer and will replace LFINPUT.

```
------------------------------ SD 16 ------------------------------
!                                                                  !
! Do you want to enter additional data, (y/n) default = y          !
!                                                                  !
------------------------------ SD 16 ------------------------------
```

How to proceed from here is explained in the manual for program LFINF.

3.2.3.2. UPDATING A FILE.

If you want to add new samples to an old file you select option 2 in SD 1 and the program will ask you for a file name. If you ask for the file "R.kanagurta.5" (assuming it has been stored on disk now) you receive the message :

```
------------------------------ SD 17 ------------------------------
!                                                                  !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank     !
!                                                                  !
!  The time series contains the samples :                          !
!                                                                  !
!   s    year    month    day      time                           !
!  ------------------------------------------                      !
!   1    1985     APR      2     1985.25205                       !
!   2    1985     APR      3     1985.25479                       !
!   3    1985     APR      4     1985.25753                       !
!   4    1985     APR      5     1985.26027                       !
!   5    1985     APR      6     1985.26301                       !
!                                                                  !
!  !RETURN!                                                        !
------------------------------ SD 17 ------------------------------
```

```
------------------------------ SD 18 ------------------------------
!                                                                  !
!          - - LENGTH FREQUENCY DATA INPUT PROGRAM - -             !
!                                                                  !
!           1 : Correct existing file.                             !
!                                                                  !
!           2 : Add new samples to existing file                   !
!                                                                  !
!           Choose option, default = 2  ! 1 !                      !
!                                                                  !
------------------------------ SD 18 ------------------------------
```

Option 2 in SD 18 carries you to the end of the file where you can enter new samples exactly as described in Subsection 3.2.3.1.

Option 1 (the option selected here) enables you to correct/change any data in the file. Option 1 produces SD 19.
In SD 19 the run-identification may be changed.

```
------------------------------ SD 19 ------------------------------
!                                                                  !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank     !
!                                                                  !
! Do you want to change the run identification,                    !
!                              (y/n) default = n  ! RETURN !       !
!                                                                  !
------------------------------ SD 19 ------------------------------
```

The sample date may be changed as shown in SD 20.

```
------------------------------ SD 20 ------------------------------
!                                                                  !
! Sample no. 1                                                     !
!                                                                  !
!          1985   APR  1   1985.24932                              !
!                                                                  !
! Do you want to change the sample date                            !
!                              (y/n) default = n  ! RETURN !       !
!                                                                  !
------------------------------ SD 20 ------------------------------
```

If you change the sample date the file is resorted into a new chronological order (if required).

Then the editing continues as described in Subsection 3.2.3.1.

Notice that you can scroll quickly through the file by using the 'e' editing command.

3.2.4. OUTPUT TO PRINTER.

LFINPUT does not produce any printer output.

Tables and bar diagrams of length frequencies are produced by the programs LFTABLE and LFBAR, respectively.
These programs can be activated by options 4 and 5 in SD 1, respectively.

3.2.5. CONNECTIONS TO OTHER PROGRAMS.

The program LFCONV can produce a file which can be input to LFINPUT.

The data files produced by program LFINPUT can be input to the programs :

LFCONV (Length frequency data conversion)

LFINF (Additional information)

LFTABLE (Length frequency tables)

LFBAR (Length frequency bar diagrams)

LFSUM (Length frequency summing)

LFMANI (Length frequency data manipulation)

LFMERGE (Length frequency file merging)

BHATTAC (Bhattacharya analysis)

3.3. LFINF.

3.3.1. PURPOSE.

LFINF is used to attach to each sample in a file what is called "additional data".
It is optional and all processing can be carried through without the use of "additional data".
The only program in the FSA package which can process some of the additional data is LFSUM, but LFSUM can also work without additional data.

By "additional data" is meant a record containing the following fields :

	Field	Size	
1	Species	----	
2	Sex (f/m)	- *	
3	Depth	---- *	The number of bars
4	Area	----	indicates the number
5	Latitude	-- *	of characters avail-
6	S/N	- *	lable in each field.
7	Minutes (lat.)	-- *	
8	Longitude	-- *	"*" indicates restric-
9	W/E	- *	tions on the field
10	Minutes (lon.)	-- *	content (see below)
11	Vessel Charac. 1	----	
12	Vessel Charac. 2	----	Other fields can con-
13	Gear type	----	tain any alpha-numeric
14	Gear Charac.	----	string of your choice
15	Time of day	---- *	
16	Bottom type	---	
17	Type of catch	---	
18	Extra	----------	
19	Effort	Any real figure. *	
20	Weight of sample	Any real figure. *	
21	Total W.of species	Any real figure. *	
22	Total W. of catch	Any real figure. *	

This choice of fields may not match your requirements for what should be recorded.
The programs LFINF and LFSUM probably require modification to match a particular fishery sampling scheme or a particular survey design.
However, with the assistance of a programmer the programs can be modified relatively easily.

As the additional data are not required for data processing you are free to fill in (nearly) anything in the additional data records (or you may leave them blank).

Those fields marked by "*" have limitations and LFINF will only accept input within certain limits in those fields. These limits are :

2. Sex. Obviously, there are only three cases which make sense
   f : Female
   m : Male
   - : Sex not known (or both sexes combined)
3. Depth : Between 1 and 9999 meters
5-10. Position :
   Latitude is in the interval 0 - 90 degrees
   Longitude is in the interval 0 - 180 degrees
   Minutes is in the interval 0 - 59 minutes.
   S/N South or North
   W/E West or East
15. Time of day : This field has the format : HHMM
   where hours (HH) is between 0 and 23
   and minutes (MM) is between 0 and 59
19-22. Effort, weight of sample, Total W. of species and Total W. of catch.
   These four fields are real figures > 0 and
   (W. of sample) < (W. of species) < (Total W.)
   "Total Weight of species" applies to the case where a sample of the catch has been taken. If all fish of the species in question were measured and nothing else was caught, then (W. of sample) = (W. of species) = (Total W.)

Weight of sample can be calculated from a weight/lenght relationship (W = q*L^b) with aid of option 6 in program LFMANI. (See Section 1.6 in the manual for LFMANI)

In the remaining part of the fields you can enter any alphanumeric string. To make the setup a little more flexible a field "extra" containing space for 20 characters has been introduced. Any additional information not covered by the named fields can be stored under "Extra".

Finally, it is stressed once again that the set-up presented here is not intended to be general enough to cover all cases. Each actual application probably requires the program to be modified.

3.3.2. INPUT/INPUT FILE.

The files are the same type as those of LFINPUT. You cannot run LFINF before you have created a file of the type

LENGTH FREQEUNCY SAMPLE

using one of the programs LFINPUT or LFCONV. Actually the program LFINPUT creates the additional data by filling in every field with blanks, so essentially LFINF is a program by which you can edit the additional data records.

3.3.3. SCREEN DIALOGUE.

You may go straight from LFINPUT to LFINF without storing the data on diskette (cf. SD 16 in the manual for LFINPUT).

SD 1 shows how to enter the first 18 fields, illustrated by the example used in the manual to LFINPUT.
When a field is empty LFINF displays a string of bars for the default indicating the available number of characters.

SD 1

```
!                                                                    !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank.      !
! Sample no. 1.  1985  APR 2   1985.25020                           !
! Options : Help 'h', Skip 's',(or 'skip') Restart 'r'              !
!                Continue 'RETURN'  !RETURN!                        !
!--------------------- Enter 'h' for 'help' enter 'd' to delete     !
!                                                        !RETURN!   !
!   Species           default = ---- ! 128 !                         !
!   Sex (f/m)         default =    - ! f   !                         !
!   Depth             default = ---- ! 60  !                         !
!   Area              default = ---- ! 3   !                         !
!   Latitude          default =   -- ! 20  !                         !
!   S/N               default =    - ! n   !                         !
!   Minutes (lat.)    default =   -- ! 9   !                         !
!   Longitude         default =   -- ! 13  !                         !
!   W/E               default =    - ! w   !                         !
!   Minutes (lon.)    default =   -- ! 40  !                         !
!   Vessel Charac. 1  default = ---- ! ras !                         !
!   Vessel Charac. 2  default = ---- ! 60  !                         !
!   Gear type         default = ---- ! btrw!                         !
!   Gear Charac.      default = ---- ! 40  !                         !
!   Time of day       default = ---- ! 0930!                         !
!   Bottom type       default =  --- ! s   !                         !
!   Type of catch     default =  --- ! r   !                         !
!   Extra             default = ------------------- !1521  3-18!    !
!   Is input ok ? (y/n) default = y  !RETURN!                        !
```

SD 1

The third and the fourth lines offer a number of options. The help option of third line produces SD 2 :

SD 2

```
!                                                                    !
!    's' : Skips the current sample and continues with the next      !
!          one.                                                      !
!  'skip': Moves you to the end of the file.                         !
!          This option enables you quickly to find a par-            !
!          ticular sample.                                           !
!                                                                    !
!    'r' : Makes you restart with sample no. 1. Values entered       !
!          so far are NOT deleted                                    !
!                                                                    !
!    'RETURN' brings you to next sample                              !
```

SD 2

With SD 3 the entering of additional data for the first sample is complete.

```
------------------------------ SD 3 ------------------------------
!                                                                !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great bank. !
! Sample no. 1.  1985  APR 2   1985.25020                        !
!--------------------- Enter 'h' for 'help' enter 'd' to delete !
!                                                      !RETURN!  !
!   Effort              default =     0.0000  1.05              !
!   Weight of sample    default =     0.0000  49.3              !
!   Total W.of species  default =     0.0000  250               !
!   Total W. of catch   default =     0.0000  2901              !
!                                                                !
!   Is input ok ? (y/n) default = y  !RETURN!                    !
!                                                                !
------------------------------ SD 3 ------------------------------
```

In SD 4 we continue with sample no. 2. Notice that the default values are those of the foregoing sample, because some of the fields may contain the same string for all samples in the file (e.g. species and sex will usually be identical for all samples). Notice further that the empty positions in the fields are filled in with zeroes, except for "extra" where the empty positions are left empty and the text is moved to the right hand side.

```
------------------------------ SD 4 ------------------------------
!                                                                !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great bank. !
! Sample no. 2.  1985  APR 3   1985.25470                        !
! Options : Help 'h', Skip 's',(or 'skip') Restart 'r'           !
!                 Continue 'RETURN'  !RETURN!                    !
!--------------------- Enter 'h' for 'help' enter 'd' to delete !
!                                                      !RETURN!  !
!   Species             default = 0128   !RETURN!                 !
!   Sex (f/m)           default =    f   !RETURN!                 !
!   Depth               default = 0060   ! 75   !                 !
!   Area                default = 0003   !RETURN!                 !
!   Latitude            default =   20   !RETURN!                 !
!   S/N                 default =    n   !RETURN!                 !
!   Minutes (lat.)      default =   09   ! 1    !                 !
!   Longitude           default =   13   !RETURN!                 !
!   W/E                 default =    w   !RETURN!                 !
!   Minutes (lon.)      default =   40   ! 52   !                 !
!   Vessel Charac. 1    default = 0ras   !RETURN!                 !
!   Vessel Charac. 2    default = 0060   !RETURN!                 !
!   Gear type           default = btrw   !RETURN!                 !
!   Gear Charac.        default = 0040   !RETURN!                 !
!   Time of day         default = 0930   ! 1100 !                 !
!   Bottom type         default =  00s   !RETURN!                 !
!   Type of catch       default =  00r   !RETURN!                 !
!   Extra               default = 1521   3-18       ! 1522 3-19 ! !
!                                                                !
!   Is input ok ? (y/n) default = y  !RETURN!                    !
!------------------------------ SD 4 ------------------------------!
```

In SD 5 the default values are zeroes, as these quantities usually differ from sample to sample.

```
------------------------------ SD 5 ------------------------------
!                                                                 !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great bank.   !
! Sample no. 2.  1985  APR 3   1985.25470                         !
!---------------------- Enter 'h' for 'help' enter 'd' to delete  !
!                                                      !RETURN!   !
!   Effort              default =      0.0000 ! 0.78  !           !
!   Weight of sample    default =      0.0000 ! 48.9  !           !
!   Total W.of species  default =      0.0000 ! 270   !           !
!   Total W. of catch   default =      0.0000 ! 2877  !           !
!                                                                 !
!   Is input ok ? (y/n) default = y  !RETURN!                     !
!                                                                 !
------------------------------ SD 5 ------------------------------
```

Having entered the additional data for all samples in the time series you eventually get SD 6 :

```
------------------------------ SD 6 ------------------------------
!                                                                 !
!        - - LENGTH FREQUENCY ADDITIONAL DATA PROGRAM - -         !
!                                                                 !
!   Do you want the tables printed (y/n), default = n             !
!                                                                 !
------------------------------ SD 6 ------------------------------
```

Answering 'y' starts the printer (see Section 3.3.4.)

SD 7 tells you that the file is being stored on diskette under the same file name by which it was retrieved.

If you are dealing with a new file (not having a name yet) you will be asked to name it.
Notice, however that if the file already has a name you cannot rename it in LFINF.

```
------------------------------ SD 7 ------------------------------
!                                                                 !
!        - - LENGTH FREQUENCY FISHERY DATA PROGRAM - -            !
!                                                                 !
!                - - P L E A S E    W A I T  - -                  !
!                                                                 !
!                  DATA BEING SAVED ON DISKETTE                   !
!                                                                 !
------------------------------ SD 7 ------------------------------
```

Eventually you get the menu shown in SD 8.

3.3.4. PRINTER OUTPUT.

Selecting the 'y'-option in SD 8 produces Tables containing additional data on the line printer. These tables are very similar to SD 1 and SD 3 combined.
The individual samples are arranged in four columns as shown in Table 3.3.4.1.

```
------------------------------ SD 8 -----------------------------
!                                                               !
!      - - LENGTH FREQUENCY ADDITIONAL DATA PROGRAM - -         !
!                                                               !
!          1 : Redo entering of additional data to this file    !
!                                                               !
!          2 : Enter additional data to another file            !
!                                                               !
!          3 : Enter lgt. frq. data     (LFINPUT)               !
!                                                               !
!          4 : Sum lgt. frq. samples    (LFSUM)                 !
!                                                               !
!          5 : Calculate sum of weights and efforts             !
!                                                               !
!          6 : Quit (return to main menu)                       !
!                                                               !
!          Choose option                                        !
!                                                               !
!------------------------------ SD 8 -----------------------------!
```

The result of option 5 is shown in SD 9.

```
------------------------------ SD 9 -----------------------------
!                                                               !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank  !
!                                                               !
!      Sample          Effort  Sample W  W of species W of catch !
! ------------------------------------------------------------- !
!  1  1985  APR  1   1.0500     49.3000     250.0000     2901.0000 !
!  2  1985  APR  2   0.7800     48.9000     270.0000     2877.0000 !
!  3  1985  APR  3   0.9500     54.0000     289.0000     2421.0000 !
!  4  1985  APR  4   1.1100     57.4000     320.0000     3819.0000 !
! ------------------------------------------------------------- !
!       Total        3.8900    209.6000    1129.0000    12018.0000 !
!       Average      0.9725     52.4000     282.2500     3004.5000 !
! ------------------------------------------------------------- !
!                                                               !
!------------------------------ SD 9 -----------------------------!
```

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Sample no.	1	2	3	4
Year	1985	1985	1985	1985
Month	APR	APR	APR	APR
Day	2	3	4	5
Time	1985.2520	1985.2547	1985.2575	1985.2602
Species	0128	0128	0128	0128
Sex (f/m)	f	f	f	f
Depth	0060	0075	0105	0090
Area	0003	0003	0003	0003
Latitude	20	20	19	19
S/N	n	n	n	n
Minutes (lat.)	09	01	57	51
Longitude	13	13	14	14
W/E	w	w	w	w
Minutes (lon.)	40	52	05	07
Vessel Charac. 1	0ras	0ras	0ras	0ras
Vessel Charac. 2	0040	0040	0040	0040
Gear type	btrw	btrw	btrw	btrw
Gear Charac.	0060	0060	0060	0060
Time of day	0930	1100	1030	1500
Bottom type	00s	00s	00s	0sr
Type of catch	00r	00r	00r	00r
Extra	1521 3-18	1522 3-19	1523 3-18	1524 3-19
Extra (cont.)				
Effort	1.0500	0.7800	0.9500	1.1100
Weight of sample	49.3000	48.9000	54.0000	57.4000
Total W.of species	250.0000	270.0000	289.0000	320.0000
Total W. of catch	2901.0000	2877.0000	2421.0000	3819.0000
C.P.U.E	238.0952	346.1538	304.2105	288.2882

Table 3.3.4.1. Printoutput from LFINF. The first four columns of additional data table corresponding to the example in the manual for LFINPUT.

5. CONNECTIONS TO OTHER PROGRAMS.

LFINF may be considered a part of program LFINPUT and produces the same sort of output as LFINPUT. The description of connections to other programs is thus the same as that given for LFINPUT.

3.4. LFTABLE.

3.4.1. PURPOSE.

The purpose of LFTABLE is to produce tables containing time series of length frequency data in a flexible format.

3.4.2. INPUT / INPUT FILE.

Input data must be a file of the type LENGTH FREQUENCY SAMPLE created by LFINPUT or LFCONV.

3.4.3. SCREEN DIALOGUE.

SD 1 shows how to select table format. SD 2 shows the result of SD 1 using the example from the manual for LFINPUT.

The default options for the frequencies result in the minimum size table.

```
------------------------------ SD 1 -------------------------------
!                                                                  !
!      - - LENGTH FREQUENCY DATA TABLE PROGRAM - -                 !
!                                                                  !
! To choose the default layout, use 'return'                       !
!                                                                  !
!           TABLE SPECIFICATIONS :                                 !
!                                                                  !
! Give format for length group columns : XXXXX.YYYYY  _______      !
!                number of Ys (default = 2)           ! 0   !     !
!                number of Xs (default = 2)           !RETURN!    !
!                                                                  !
!                                        - - please wait - -       !
!                                                                  !
! Give format for length group columns : XXXXX.YYYYY  _______      !
!                number of Ys (default = 0)           !RETURN!    !
!                                                                  !
! The sum of all observations is                      5315         !
! so the number of Xs must be at least                5            !
!                number of Xs (default = 5)           !RETURN!    !
!                                                                  !
! Maximum number of columns                           5            !
! Give number of columns (default = 5)                !RETURN!    !
!                                                                  !
! Is input ok ? (y/n) default = y  !RETURN!                        !
!                                                                  !
------------------------------ SD 1 -------------------------------
```

```
------------------------------ SD 2 -------------------------------
!                                                                  !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank     !
!                                                                  !
!   year   1985 1985 1985 1985 1985                               !
!  month      4    4    4    4    4                               !
!    day      2    3    4    5    6      Total                    !
! ---------------------------------------------                    !
!    6- 8    25   18   24   19   23        109                    !
!    8-10   120  135  125  128  130        638                    !
!   10-12    19   21   15   28   22        105                    !
!   12-14   100   70   85   86   81        422                    !
!   14-16   222  271  301  283  278       1355                    !
!   16-18   171  158  243  208  262       1042                    !
!   18-20   138  140  109  152  153        692                    !
!   20-22   100   88  117  105  117        527                    !
!   22-24    49   67   56   58   49        279                    !
!   24-26    15   24   17   34   22        112                    !
!   26-28     9    4    5    7    6         31                    !
!   28-30     0    1    0    1    1          2                    !
! ---------------------------------------------                    !
! Total     968  997 1097 1109 1144       5315                    !
!                                                                  !
! Do you want the table printed (y/n), default = y !RETURN!        !
!                                                                  !
------------------------------ SD 2 -------------------------------
```

3.4.4. PRINTER OUTPUT.

The printer output is in exactly the same format as the screen displays.
Table 3.4.4.1 shows an example of a table with the same data as that of SD 2 but with a different format.

3.4.5. CONNECTIONS TO OTHER PROGRAMS.

LFTABLE does not produce output to the diskette, so it is not followed by other programs.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

year	1985	1985	1985	1985
month	4	4	4	4
day	2	3	3	5
6- 8	25.00	18.00	24.00	19.00
8-10	120.00	135.00	125.00	128.00
10-12	19.00	21.00	15.00	28.00
14-16	222.00	271.00	301.00	283.00
16-18	171.00	158.00	243.00	208.00
18-20	138.00	140.00	109.00	152.00
20-22	100.00	88.00	117.00	105.00
22-24	49.00	67.00	56.00	58.00
24-26	15.00	24.00	17.00	34.00
26-28	9.00	4.00	5.00	7.00
28-30	0.00	1.00	0.00	1.00
Total	968.00	997.00	1097.00	1109.00

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

year	1985	
month	4	
day	6	Total
6- 8	23.00	109.00
8-10	130.00	638.00
10-12	22.00	105.00
12-14	81.00	422.00
14-16	278.00	1355.00
16-18	262.00	1042.00
18-20	153.00	692.00
20-22	117.00	527.00
22-24	49.00	279.00
24-26	22.00	112.00
26-28	6.00	31.00
28-30	1.00	2.00
Total	1144.00	5315.00

Table 3.4.4.1. Example of printer output from LFTABLE.

3.5. LFBAR.

3.5.1. PURPOSE.

The purpose of LFBAR is to depict length frequency samples by bar diagrams for display on screen and printer, with dimensions specified by the user.

3.5.2. INPUT / INPUT FILE.

The input file must be of the type "LENGTH FREQUENCY SAMPLE" created by LFINPUT or LFCONV.

3.5.3. SCREEN DIALOGUE.

After retrieval of the data file SD 1 appears. The options chosen in SD 1 produces the minimum sized bar diagram shown in SD 2 which shows the bar diagram for sample no. 2 of the example used in the manual to LFINPUT.

```
---------------------------- SD 1 -----------------------------
!                                                             !
!      - - LENGTH FREQUENCY BAR DIAGRAM PROGRAM - -           !
!                                                             !
!  Give height of bars (in number of lines)                   !
!                                                             !
!  10, 20, 30, 40, 50, 60, 70, 80, 90 or 100                  !
!                                                             !
!  (default = 'screen size')          ! 10 !                  !
!                                                             !
!                           1      2      4   bar-width       !
!                                                             !
!                           #      #I    I##I                 !
!                           #      #I    I##I                 !
!                                                             !
!  Give bar width (1, 2 or 4)         ! 1 !                   !
!                                                             !
!  Is input ok ? (y/n) default = y  !RETURN!                  !
!                                                             !
---------------------------- SD 1 -----------------------------
```

In the next section two bar diagrams with different dimensions are shown.

```
------------------------------ SD 2 -------------------------------
!                                                                  !
!   3 APR 1985  time 1985.25479                                    !
!   Total sample size : 997     Max freq. 271                      !
!                                                                  !
!       I Freq. relative to highest freq.                          !
!  100% I    #                                                     !
!   90% I    #                                                     !
!   80% I    #                                                     !
!   70% I    #                                                     !
!   60% I    #                                                     !
!   50% I    ###                                                   !
!   40% I #  ###                                                   !
!   30% I #  ####                                                  !
!   20% I # ######                                                 !
!   10% I # ######                                                 !
!    0% I----+----+----+--->                                       !
!       6        22                                                !
!                                                                  !
! Do you want the diagram on printer (y/n) default = y !RETURN!    !
!                                                                  !
------------------------------ SD 2 -------------------------------
```

3.5.4. PRINTER OUTPUT.

All bar diagrams displayed on the screen can be displayed on printer as well, as can be seen from the last line in SD 2. Figure 3.5.4.1 shows the printer version corresponding to a screen size bar diagram (i.e. the diagram produced by the default option in SD 2).

Figure 3.5.4.2 shows a bar diagram at maximum size. This diagram is printed in separate parts, which were subsequently put together and reduced in size. To obtain this sort of graph a larger number of intervals than that of the example of Figure 3.5.4.2 is required. Thus, Figure 3.5.4.2 is not the same length frequency sample as Figure 3.5.4.1.

3.5.5. CONNECTIONS TO OTHER PROGRAMS.

LFBAR does not produce input for other programs.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

3 APR 1985 time 1985.25479
Total sample size : 997 Max freq. 271

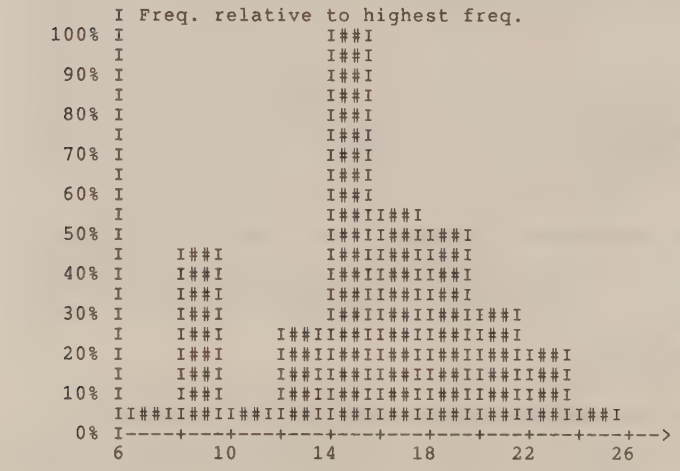


Figure 3.5.4.1. Printer version of the screen-sized bar diagram shown in SD 2. (The only difference between the printer version and the screen version is that the first one contains the run identification).

Nemipterus japonicus.

4 APR 1978 time 1978.25753
Total sample size : 4519 Max freq. : 334

I Freq. relative to highest freq.

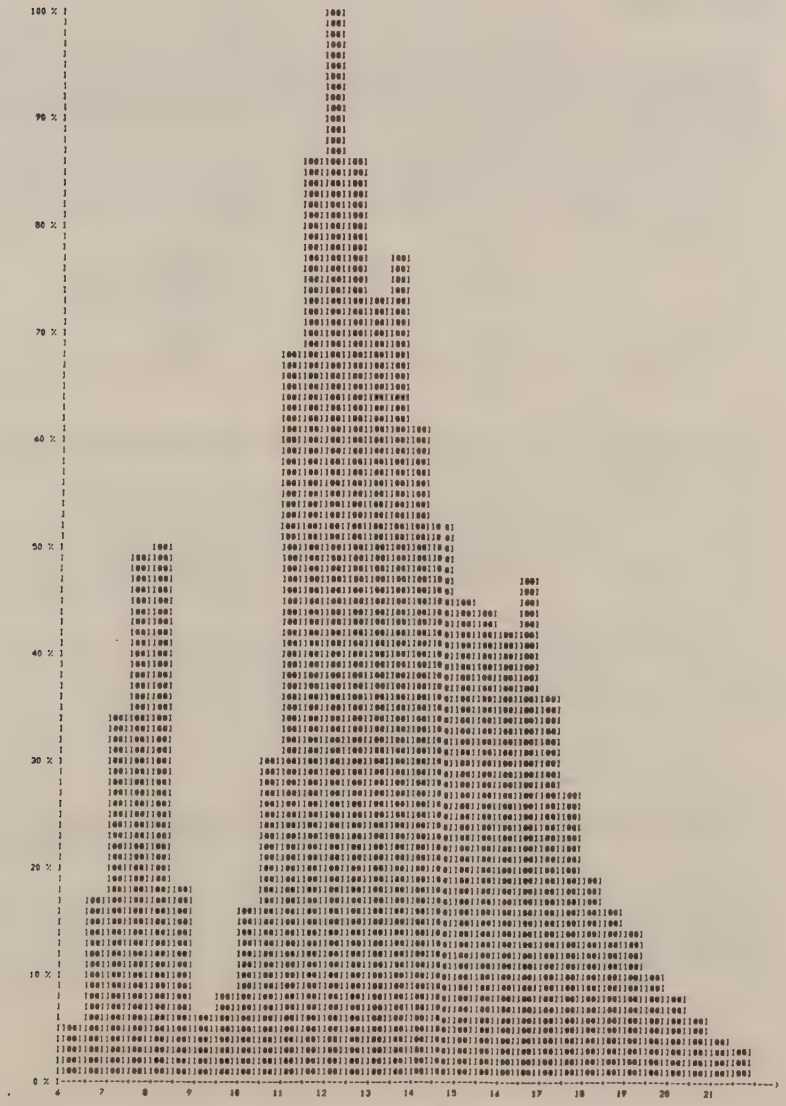


Figure 3.5.4.2. Printer version of maximum size graph. Printed in two parts which were subsequently put together and reduced in size.

3.6. LFSUM.

3.6.1. PURPOSE.

The purpose of LFSUM is to calculate weighted sums of samples contained in one length frequency file.
Let FRQ(s,i) be the frequency of length group i in sample s. Essentially all LFSUM does is to calculate the weighted sum of n samples weighting by the factors W(s), s = 1,2,...,n.

$$SUM(i) = \sum_{s=1}^{n} FRQ(s,i)\ W(s) \qquad \text{for each length group.}$$

For example :

i	W(1) = 2 FRQ(1,i)	W(2) = 3 FRQ(2,i)	Weighted sum SUM(i)
1	5	7	31
2	10	13	59
3	2	4	16
:	:	:	:
:	:	:	:

You are free to assign any value to the weighting factors W(s). LFSUM offers you three options :

1 . To weight by catch per unit of effort. In this case :

$$W(s) = \frac{\text{Total weight of species}}{\text{Effort}} * \frac{1}{\sum_{i} FRQ(s,i)}$$

where "total weight of species" and "effort" are values entered as "additional" data by program LFINF.

2 . To raise to total catch of species. In this case :

$$W(s) = \frac{\text{Total weight of species}}{\text{Weight of sample}}$$

where "total weght of species" and "weight of sample" are values entered as "additional" data by program LFINF.

3. Any weighting factor as defined by the user on :

3.1. Absolute frequencies.

3.2. Relative frequencies (i.e. $FRQ(s,i) / \sum_{j} FRQ(s,j)$

When summing a number a samples LFSUM will calculate the mean time of sampling and convert it into a date.

If additional data are available LFSUM will calculate the mean depth and the mean position. Effort, sample weight, total weight of species and total weight of catch will be summed.

LFSUM works on subsets of time series. That is, you can convert a time series of, say, 25 samples into a time series of, say, 5 samples by adding subsets consisting of, say, 5 samples each.

LFSUM is intended to be useful for combining many small samples (the raw data) into larger samples. When estimating fish stock assessment parameters you will usually not work directly on the raw data but on frequencies composed of a large number of samples.

3.6.2. INPUT / INPUT FILE.

The input file must be of the type LENGTH FREQUENCY SAMPLE created by LFINPUT/LFINF. (See examples in manuals for LFINPUT and LFINF).

3.6.3. SCREEN DIALOGUE.

The example used to illustrate the dialogue is that of the manuals for LFINPUT and LFINF.
Having retrieved the data file SD 1 appears.
In SD 1 you are required to enter the weighting factors as defined in the introduction.

```
------------------------------ SD 1 ------------------------------
!                                                                 !
! Enter 'c' for CPUE, 'r' for relative, 't' for total,           !
!                                       'h' for 'help'            !
!  s  year month day  time      SELECT/weighting                  !
! ---------------------------------------------                   !
!  1  1985   APR  2  1985.2520       ! h !                        !
!                                                                 !
------------------------------ SD 1 ------------------------------
```

To explain the procedure we choose the help-option in SD 1 and get SD 2.

Suppose we want to calculate the sum of the five samples weighted by CPUE, the dialogue should be as shown in SD 3.
If the relevant additional data are not available (i.e. Effort and Total weight of species) you will get a warning message and no summing will be performed.

```
------------------------------ SD 2 ------------------------------
!                                                                 !
! To select samples for summing you have the options :            !
!                                                                 !
!  <value>     : This value used as weighting factcr for the      !
!                ORIGINAL frequency sample.                       !
!                                                                 !
! r <value>    : This value used as weighting factor for the      !
!                RELATIVE frequency sample.                       !
!                (Rel.frq.) = (Orig. frq.)/(sum of Orig. frq.)    !
!                                                                 !
! c              CPUE used as weighting factor on the RELATIVE    !
!                frequencies. CPUE is derived from additional     !
!                data by : CPUE = (Total W. of species)/Effort    !
!                                                                 !
! t              (Total Weight of species)/(Weight of sample)     !
!                is used as weighting (raising) factor.           !
!                ("Total weight of species" is the total weight   !
!                of the species represented by the sample)        !
!                                                                 !
------------------------------ SD 2 ------------------------------
```

```
------------------------------ SD 3 ------------------------------
!                                                                 !
! Enter 'c' for CPUE, 'r' for relative, 't' for total,            !
!                                        'h' for 'help'           !
!                                                                 !
!  s  year month day  time      SELECT/weighting                  !
! ------------------------------------------------                !
!  1  1985   APR  2  1985.2520       ! c !                        !
! n = 968   Effort = 1.05 Weight of catch = 250 CPUE/n = .2460    !
!  2  1985   APR  3  1985.2547       ! c !                        !
! n = 997   Effort = 0.78 Weight of catch = 270 CPUE/n = .3472    !
!  3  1985   APR  4  1985.2575       ! c !                        !
! n = 1097  Effort = 0.95 Weight of catch = 289 CPUE/n = .2773    !
!  4  1985   APR  5  1985.2602       ! c !                        !
! n = 1109  Effort = 1.11 Weight of catch = 320 CPUE/n = .2599    !
!  5  1985   APR  6  1985.2630       ! c !                        !
! n = 1144  Effort = 1.01 Weight of catch = 380 CPUE/n = .3289    !
!                                                                 !
! Is input ok ? (y/n) default = y  !RETURN!                       !
!                                                                 !
------------------------------ SD 3 ------------------------------
```

The program then performs the summing and displays the message shown in SD 4. Notice that the time of the pooled sample is the mean time of the five original samples.

```
------------------------------ SD 4 ------------------------------
!                                                                !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank   !
!                                                                !
! The summed time series contains the samples                    !
!                                                                !
!  s   year   month  day     time                                !
! ------------------------------------                           !
!  1   1985    APR    4   1985.2575                              !
!                                                                !
!  !RETURN!                                                      !
------------------------------ SD 4 ------------------------------
```

To illustrate some other features of LFSUM, suppose we want to sum separately all samples from depths less than and greater than 80 meters (compare Section 4 in the manual to LFINF). Suppose further that we want to weight by the raising factor, (Total weight of species)/(Weight of sample), for those samples from depths less than 80 m, the dialogue should be as shown in SD 5, which is followed by the message in SD 6.

```
------------------------------ SD 5 ------------------------------
!                                                                !
! Enter 'c' for CPUE, 'r' for relative, 't' for total,           !
!                                       'h' for 'help'           !
!  s  year month day  time      SELECT/weighting                 !
! ---------------------------------------------                  !
!  1  1985   APR  2  1985.2520      ! t !                        !
! Sample W. 49.3 Total W. of species 250   Raising fac.  5.071   !
!  2  1985   APR  3  1985.2547      ! t !                        !
! Sample W. 48.9 Total W. of species 270   Raising fac.  5.521   !
!  3  1985   APR  4  1985.2575      !RETURN!                     !
!  4  1985   APR  5  1985.2602      !RETURN!                     !
!  5  1985   APR  6  1985.2630      !  t  !                      !
! Sample W. 56.4 Total W. of species 380   Raising fac.  6.738   !
!                                                                !
! Is input ok ? (y/n) default = y  !RETURN!                      !
!                                                                !
------------------------------ SD 5 ------------------------------
```

```
------------------------------ SD 6 ------------------------------
!                                                                !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank   !
!                                                                !
! The summed time series contains the samples                    !
!                                                                !
!  s   year   month  day     time                                !
! ------------------------------------                           !
!  1   1985    APR    4   1985.2566                              !
!                                                                !
!  !RETURN!                                                      !
------------------------------ SD 6 ------------------------------
```

We have used three of the five samples which leaves us with the two samples shown in SD 7. For illustration purposes only, we weight the first sample by the factor 2 and the second one by 2000/> FRQ.

```
------------------------------ SD 7 ------------------------------
!                                                                 !
! Enter 'c' for CPUE, 'r' for relative, 't' for total,            !
!                                       'h' for 'help'            !
!  s  year month day  time      SELECT/weighting                  !
! ------------------------------------------------                !
!  3  1985   APR  4  1985.2575       ! 2      !                   !
!  4  1985   APR  5  1985.2602       ! r2000 !                    !
!                                                                 !
! Is input ok ? (y/n) default = y  !RETURN!                       !
!                                                                 !
------------------------------ SD 7 ------------------------------
```

SD 8 shows that the time series of summed frequencies contains two samples.

```
------------------------------ SD 8 ------------------------------
!                                                                 !
! Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank    !
!                                                                 !
! The summed time series contains the samples                     !
!                                                                 !
!  s   year   month  day     time                                 !
! ---------------------------------                               !
!  1   1985    APR    4   1985.2566                               !
!  1   1985    APR    5   1985.2589                               !
!                                                                 !
!  !RETURN!                                                       !
------------------------------ SD 8 ------------------------------
```

3.6.4. PRINTER OUTPUT.

The first case illustrated in Section 3 produces the printer table shown in Table 3.6.4.1. Notice that the depth is the mean of all five samples :

$$(60 + 75 + 105 + 90 + 68) / 5 = 80 \text{ m}$$

The position is the mean position. For the latitude :

$$(20+9/60+20+1/60+19+57/60+19+51/60+19+55/69) / 5 = 19.977$$

Thus, the mean latitude is 19 degrees and 59 minutes as 60*.977 = 59 minutes.
The longitude is treated in a similar way.

The effort, weight of sample, total W. of species and total W. of catch are the summed values.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Sample no.	1
Year	1985
Month	APR
Day	4
Time	1985.2575
Species	0128
Sex (f/m)	f
Depth	0080
Area	0003
Latitude	19
S/N	n
Minutes (lat.)	59
Longitude	14
W/E	w
Minutes (lon.)	00
Vessel Charac. 1	0ras
Vessel Charac. 2	0040
Gear type	btrw
Gear Charac.	0060
Time of day	++++
Bottom type	+++
Type of catch	00r
Extra	++++++++++
Extra (cont.)	++++++++++
Effort	4.9000
Weight of sample	266.0000
Total W.of species	1509.0000
Total W. of catch	16524.0000
C.P.U.E	307.9591

These summed freq. were created with data from file R.KANAGURTA.5
Run-identification :
Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Sum sample	Summing spec. : (Weight. fac. , 'r' rel. frq., 'c' CPUE, 't' total)
1	1:c -- 2:c -- 3:c -- 4:c -- 5:c

The initial file contained the samples :

s	year	month	day	time
1	1985	APR	2	1985.2520
2	1985	APR	3	1985.2547
3	1985	APR	4	1985.2575
4	1985	APR	5	1985.2602
5	1985	APR	6	1985.2630

Table 3.6.4.1. Printoutput from LFSUM corresponding to SD 3.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Sample no.	1	2
Year	1985	1985
Month	APR	APR
Day	4	4
Time	1985.2566	1985.2589
Species	0128	0128
Sex (f/m)	f	f
Depth	0068	0098
Area	0003	0003
Latitude	20	19
S/N	n	n
Minutes (lat.)	02	54
Longitude	13	14
W/E	w	w
Minutes (lon.)	56	06
Vessel Charac. 1	0ras	0ras
Vessel Charac. 2	0040	0040
Gear type	btrw	btrw
Gear Charac.	0060	0060
Time of day	++++	++++
Bottom type	+++	+++
Type of catch	00r	00r
Extra	++++++++++	++++++++++
Extra (cont.)	++++++++++	++++++++++
Effort	2.8400	2.0600
Weight of sample	154.6000	111.4000
Total W.of species	900.0000	609.0000
Total W. of catch	10284.0000	6240.0000
C.P.U.E	316.9014	295.6310

These summed freq. were created with data from file R.KANAGURTA.5
Run-identification :
Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Sum sample	Summing spec. : (Weight. fac. , 'r' rel. frq., 'c' CPUE, 't' total)
1	1:t -- 2:t -- 5:t
2	3:2 -- 4:r2000

The initial file contained the samples :

s	year	month	day	time
1	1985	APR	2	1985.2520
2	1985	APR	3	1985.2547
3	1985	APR	4	1985.2575
4	1985	APR	5	1985.2602
5	1985	APR	6	1985.2630

Table 3.6.4.2. Printoutput from LFSUM corresponding to SD 5 and SD 7.

If an alphanumeric field contains the same string in all samples this string is kept in the summed sample. If they differ the field is filled in with "+++" (cf. e.g. the field "Bottom type")

The lower part of the table lists the options chosen for the summation.

3.6.5. CONNECTIONS TO OTHER PROGRAMS.

To get a screen display or a printed table of the summed frequencies you should run the program LFTABLE. The result (in case of the options in SD 3, Table 3.6.4.1) is shown in Table 3.6.5.1.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

Year	1985	
Month	4	
Day	4	Total
6 - 8	31.55	31.55
8 -10	187.08	187.08
10-12	30.63	30.63
12-14	121.46	121.46
14-16	397.16	397.16
16-18	304.54	304.54
18-20	202.61	202.61
20-22	153.37	153.37
22-24	82.03	82.03
24-26	32.81	32.81
26-28	8.78	8.78
Total	1551.98	1551.98

Table 3.6.5.1. Printoutput from LFTABLE corresponding to LFSUM options of SD 3, Table 3.6.4.1.

The files created by LFSUM have the same format as those created by LFINPUT / LFINF and LFSUM is thus connected to the same programs as LFINPUT / LFINF.

3.7. LFCONV.

3.7.1. PURPOSE.

LFCONV is used to enter raw data which are based on measurements different from those having been used so far in your data base.

E.g. if you usually measure length as fork length and you come across some data given as, say, total lengths, you would like the latter ones to be converted into fork lengths.

Obviously, all length frequencies in a time series must be expressed by the same measure before they are pooled.

Further, all LF-programs assume the length groups within a time series to be of equal size. You may use 0.5 cm groups, 1 cm groups or any other interval size you prefer, but you cannot work with variable interval size within the individual time series.

LFCONV offers three alternative ways of converting data.

Let L be the symbol for the length measure in which you want your data expressed. Let X be the measure in which your data are given. The three types of data transformation can be expressed :

A : $X \longrightarrow L$

B : $X \longrightarrow a + b\,X = L$

C : $X \longrightarrow a\,X^{b} = L$

A: This case refers to the example where X is given in the same measure, say, fork length, as L but with different length interval classes. E.g. :

L	X1	X2
5 - 6	4.75 - 5.25	5.0 - 5.5
6 - 7	5.25 - 5.75	5.5 - 6.5
7 - 8	5.75 - 6.25	6.5 - 7.5
8 - 9	6.25 - 6.75	7.5 - 8.5
9 -10	6.75 - 7.25	8.5 -10.0
:	:	:

In case X1 the intervals are of equal size but different from L. In case X2 the intervals are of different sizes.

B: This transformation contains A as a special case, namely if a = 0 and b = 1. Transformation B can be used to convert
Total length into fork length
Fork length into total length
Standard length into fork length
.....
etc.

C : This transformation contains case A as a special case, namely if a = b = 1.

It can be used to transform e.g. weight frequency data into length frequency data.

The conversion technique applied by LFCONV is the simplest possible one as illustrated by Figure 3.7.1.1.

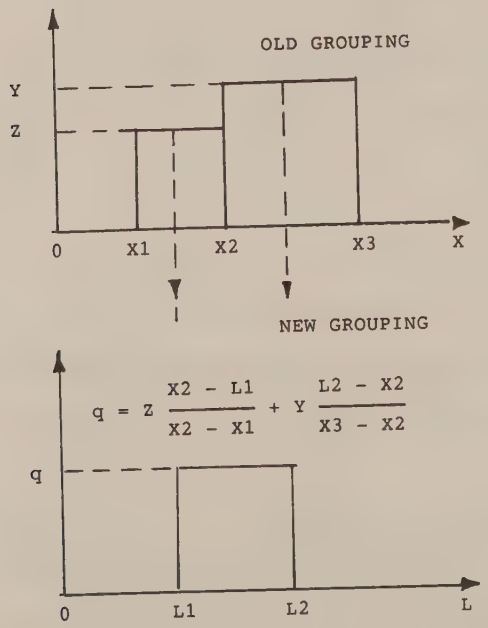


Figure 3.7.1.1. The conversion technique used by LFCONV.

The technique is further explained by the examples given below in Figures 3.7.1.2, 3.7.1.3 and 3.7.1.4.

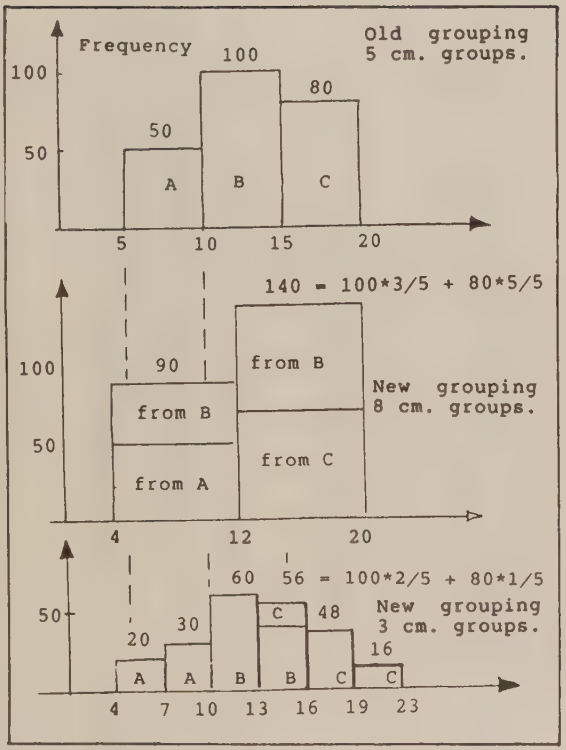


Figure 3.7.1.2.
Illustration of conversion case A.

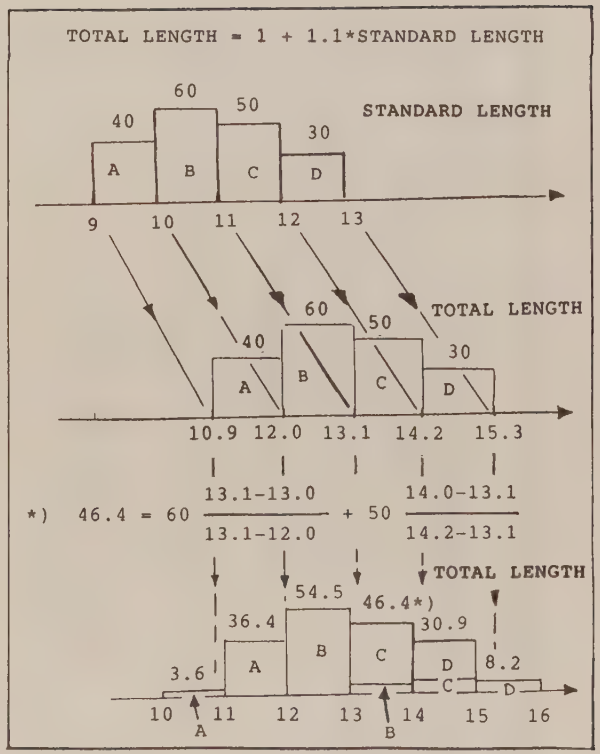


Figure 3.7.1.3. Illustration of conversion case B with a = 1.0 and b = 1.1.

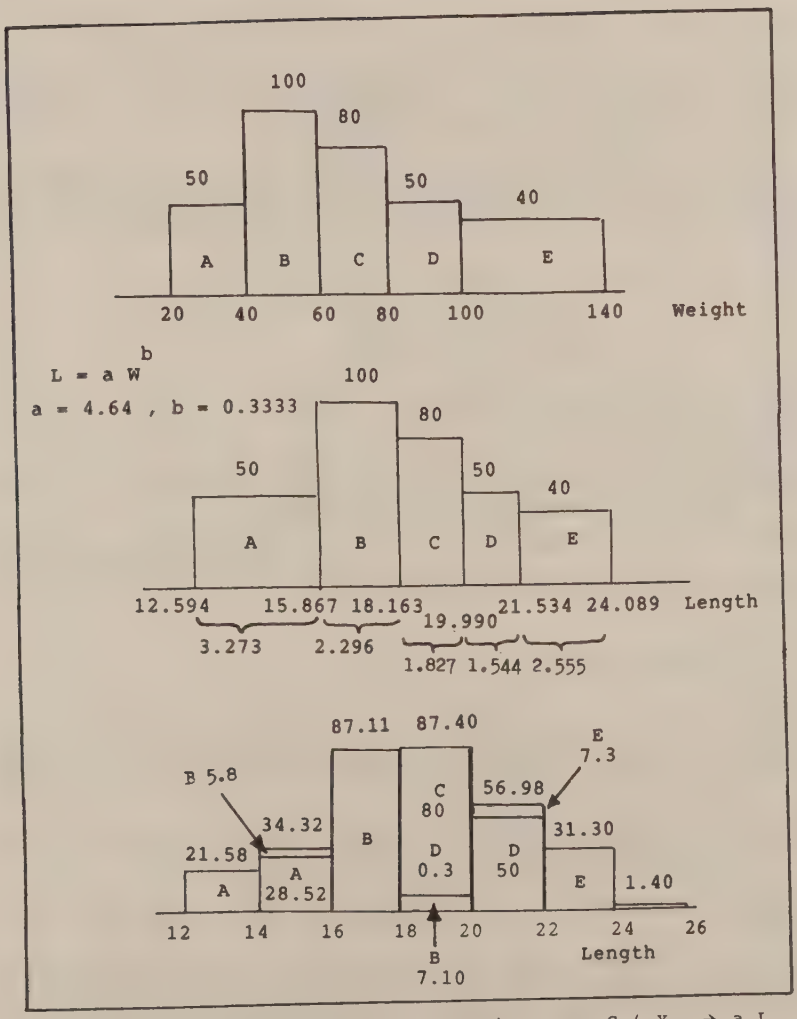


Figure 5.7.1.4. Illustration of conversion case C (X ⟶ a L). with a = 4.64 and b = 0.3333

3.7.2. INPUT / INPUT FILE.

Input data to LFCONV are of the same type as those for LFINPUT, i.e. "raw" frequency data, but LFCONV can handle more different types of frequency data than LFINPUT can.

Input data to LFCONV is either entered from the keyboard or both from keyboard and disk. If you start from scratch creating a new file all input is entered from the keyboard. You may also start by retrieving a file created earlier by LFCONV (or by LFINPUT).

The type of data file created by LFCONV is either

LENGTH CONV. DATA

or

LENGTH FREQUENCY SAMPLE

The data type becomes "LENGTH CONV. DATA" if you save the data before they are converted.

If you save the data after conversion they are of the the type "LENGTH FREQUENCY SAMPLE" and the file can be read by LFINPUT (and all other programs connected to LFINPUT).

Data of the type "LENGTH CONV. DATA" can only be read by LFCONV.

You may if you wish keep a copy of the data both before and after conversion.

3.7.3. SCREEN DIALOGUE.

Program LFCONV is an extended version of program LFINPUT. In the following it will be assumed that the reader is familiar with LFINPUT, and only features of LFCONV representing extensions of LFINPUT will be illustrated.

SD 1 shows the first menu displayed by LFCONV. To enter a file with weight frequency data from scratch, we select option 1. As an example we use the data given in Figure 3.7.1.4.

In SD 2 you enter the run-identifiacation as was the case with LFINPUT.

In SD 3 you select option 2 as the weight intervals are of different sizes (Compare Figure 3.7.1.4). In SD 4 you enter the limits for the length groups and in SD 5 you check the input data.

```
---------------------------- SD 1 -----------------------------
!                                                             !
!       - - FREQUENCY DATA CONVERSION PROGRAM - -             !
!                                                             !
!               1 : Enter new file                            !
!                                                             !
!               2 : Correct or amend old file                 !
!                                                             !
!               3 : Convert data                              !
!                                                             !
!               4 : Quit (return to main menu)                !
!                                                             !
!               5 : Help                                      !
!                                                             !
!           (1 or 2 must be executed before 3)                !
!                                                             !
!           Choose option  ! 1 !                              !
!                                                             !
---------------------------- SD 1 -----------------------------

---------------------------- SD 2 -----------------------------
!                                                             !
!       - - FREQUENCY DATA CONVERSION PROGRAM - -             !
!                                                             !
! Give run identification (max 255 Characters, min. 1 char.)  !
!                                                             !
! ! EXAMPLE FROM FIGURE 1.4 !                                 !
!                                                             !
---------------------------- SD 2 -----------------------------

---------------------------- SD 3 -----------------------------
!                                                             !
!             SPECIFY LENGTH GROUPS                           !
!                                                             !
!               1 : All intervals equal                       !
!                                                             !
!               2 : Variable interval size                    !
!                                                             !
!           Choose option  ! 2 !                              !
!                                                             !
---------------------------- SD 3 -----------------------------

---------------------------- SD 4 -----------------------------
!                                                             !
! Enter lower limit of groups, terminate by 'e'               !
!                                                             !
! Give lower limit of group 1   !  20  !                      !
! Give lower limit of group 2   !  40  !                      !
! Give lower limit of group 3   !  60  !                      !
! Give lower limit of group 4   !  80  !                      !
! Give lower limit of group 5   !  100 !                      !
! Give lower limit of group 6   !  e   !                      !
! Give UPPER limit of group 5   !  140 !                      !
!                                                             !
---------------------------- SD 4 -----------------------------
```

```
---------------------------- SD 5 -------------------------------
!                                                                !
!    i      L(i)      L(i+1)      Interval length                !
!   ------------------------------------------                   !
!     1    20.0000 - 40.0000        20.00000                     !
!     2    40.0000 - 60.0000        20.00000                     !
!     3    60.0000 - 80.0000        20.00000                     !
!     4    80.0000 -100.0000        20.00000                     !
!     5   100.0000 -140.0000        40.00000                     !
!                                                                !
!  Is input ok ? (y/n) default = y  !RETURN!                     !
!                                                                !
---------------------------- SD 5 -------------------------------
```

Then follows the entering of data which follows exactly the same procedure as for LFINPUT (see SD 3-5 in the manual for LFINPUT).
At this stage you get the option to save the data on disk (data before conversion).

After entering of the raw data the menu in SD 1 reappears and now you select option 3, which produces SD 6.

```
---------------------------- SD 6 -------------------------------
!                                                                !
!       - - FREQUENCY DATA CONVERSION PROGRAM - -                !
!                                                                !
!  1 : L.new = A + B*L.old                                       !
!      E.g. from fork length (L.old) to total length (L.new)     !
!                                                                !
!  2 : L.new = a*X.old^B                                         !
!      E.g. from weight (X.old) to length (L.new)                !
!                                                                !
!  3 : L.new defined by lower limit of first length group and    !
!      interval size.                                            !
!                                                                !
!            Choose option  ! 2 !                                !
!                                                                !
!      Give A      ! 4.64 !                                      !
!                                                                !
!      Give B      ! .333 !                                      !
!                                                                !
!  Specify new length groups                                     !
!                                                                !
!  Give lower limit of first length group ! 12 !                 !
!  Give length interval size              !  2 !                 !
!                                                                !
!  Is input ok ? (y/n) default = y  !RETURN!                     !
!                                                                !
---------------------------- SD 6 -------------------------------
```

In the present case we select option 2 and enter the values for a and b and the length group specification corresponding to Figure 3.7.1.4. SD 6 is then followed by SD 7 which shows you the three groupings required to go from weight groups to length groups.

```
--------------------------- SD 7 -----------------------------
!                                                            !
!     i      L-start      L-old       L-new                  !
!   ------------------------------------------               !
!     1      20.0000      12.5936     12.0000                !
!     2      40.0000      15.8666     14.0000                !
!     3      60.0000      18.1625     16.0000                !
!     4      80.0000      19.9902     18.0000                !
!     5     100.0000      21.5336     20.0000                !
!     6     140.0000      24.0892     22.0000                !
!                                                            !
!  Is input ok ? (y/n) default = y  !RETURN!                 !
!                                                            !
! Do you want to monitor the conversion process (y/n)        !
!                                        default = n  ! y !  !
!                                                            !
--------------------------- SD 7 -----------------------------
```

If you want to be sure that you are doing the correct thing you may monitor the conversion process as shown in SD 8 (Compare Figure 3.7.1.4) ."P" is the fraction from the old group, Frq., transferred to the new group.

3.7.4. PRINTER OUTPUT.

As was the case for LFINPUT, LFCONV does not produce any printer output.

3.7.5. CONNECTIONS TO OTHER PROGRAMS.

As LFCONV produces the same sort ot files as LFINPUT the two programs has exactly the same connections to other programs.

```
------------------------------ SD 8 ------------------------------
!                                                                !
! Sample no. 1                                                   !
!                                                                !
! New index 1   12 - 14                                          !
! Old index 1   12.5936 - 15.8666  Frq = 50 P = .4297            !
!                                  New Frq. 21.4844    !RETURN!  !
! New index 2   14 - 16                                          !
! Old index 1   12.5936 - 15.8666  Frq =  50 P = .5703           !
! Old index 2   15.8666 - 18.1625  Frq = 100 P = .0581           !
!                                  New Frq. 34.3249    !RETURN!  !
!                                                                !
! New index 3   16 - 18                                          !
! Old index 2   15.8666 - 18.1625  Frq = 100 P = .8711           !
!                                  New Frq. 87.1125    !RETURN!  !
!                                                                !
! New index 4   18 - 20                                          !
! Old index 2   15.8666 - 18.1625  Frq = 100 P = .0708           !
! Old index 3   18.1625 - 19.9902  Frq =  80 P = 1.0000          !
! Old index 4   19.9902 - 21.5337  Frq =  50 P = .0063           !
!                                  New Frq. 87.3946    !RETURN!  !
!                                                                !
! New index 5   20 - 22                                          !
! Old index 4   19.9902 - 21.5337  Frq =  50 P = .9937           !
! Old index 5   21.5337 - 24.0892  Frq =  40 P = .1825           !
!                                  New Frq. 56.9828    !RETURN!  !
!                                                                !
! New index 6   22 - 24                                          !
! Old index 5   21.5337 - 24.0892  Frq =  40 P = .7826           !
!                                  New Frq. 31.3046    !RETURN!  !
!                                                                !
! New index 7   24 - 26                                          !
! Old index 5   21.5337 - 24.0892  Frq =  40 P = .0349           !
!                                  New Frq.  1.3963    !RETURN!  !
!                                                                !
------------------------------ SD 8 ------------------------------
```

3.8. LFMANI.

3.8.1. PURPOSE.

The purpose of LFMANI is to do various manipulations with length frequency data. Six options are offered :

3.8.1.1. CALCULATION OF WEIGHTED SUM OF SAMPLES.

In this case the result becomes one single length frequency which is the weighted sum of all frequencies in the time series. You are free to use any weighting factors, e.g. you may exclude individual samples by assigning them the weight 0).

The length frequency sample created by this procedure forms the input to the catch curve analyses, i.e. CCURVE, BHZWET, JONZAL and LCOHOR. To prevent violation of the assumptions behind the catch curve methods the user is forced to let the data pass through the summation process of program LFMANI before any catch curve analysis can be performed.

3.8.1.2. CHANGE INTERVAL SIZE.

Using this option you may double, treble, ... etc. the interval size. (If you want to do more complicated changes of the grouping you must use the program LFCONV).

3.8.1.3. CONVERT INTO RELATIVE FREQUENCIES.

This option converts all frequencies FRQ(s,i) (s is index of sample and i is index of length group) into :

$$100000 \frac{FRQ(s,i)}{\sum_{j} FRQ(s,j)}$$

i.e. the relative frequency multiplied by 100000

3.8.1.4. CHANGE LOWER LIMIT OF FIRST LENGTH GROUP.

This option applies to the case where you extend the length range below the lower limit so far in use. (You can do the same thing using program LFCONV but it is easier to do it with LFMANI).

3.8.1.5 ADJUSTMENT FOR SELECTION.

This option transforms the frequency FRQ(s,i) (s is index of sample and i is index of length group) into

$$FRQ(s,i)/S(Li)$$

where

S(Li) = The fraction of the population under full exploitation (i.e. S is the "resultant" selection curve). S is given by the logistic curve : $S(Li) = 1/(1 + \exp(s1 - s2*Li))$

Li = midpoint of length interval no. i

s1 and s2 are constants defined by
$s2 = \ln(3)/(L75\%-L50\%)$ and $s1 = L50\%*s2$

L50% and L75% are the 50 % and 75 % selection lengths respectively.

3.8.1.6. ESTIMATE WEIGHT OF SAMPLE USING W = A*L^B

If the weight of the sample is unknown this option allows you to estimate it by

$$(\text{Weight of sample s}) = \sum_i FRQ(s,i)*A*Li^B$$

where FRQ(s,i) = frequency of length group i in sample s
Li = midpoint of interval no i.
A and B are constants.

The values calculated will be kept in the "additional data".

3.8.2. INPUT / INPUT FILE.

Input is a file of the type "LENGTH FREQUENCY SAMPLE" created by programs LFINPUT or LFCONV.

3.8.3. SCREEN DIALOGUE.

The menu after retrieval of the data file is shown in SD 1.

SD 2 - 4 show how to sum the samples, i.e. option 1 in SD 1. To illustrate the summing process the example from the manual of LFINPUT is used.

```
---------------------------- SD 1 -----------------------------
!                                                             !
!     - - MANIPULATION OF LENGTH FREQUENCIES - -              !
!                                                             !
!      1 : CALCULATE WEIGHTED SUM OF SAMPLES                  !
!          ================================                   !
!          (Prepare data for catch curve analysis)            !
!                                                             !
!      2 : CHANGE INTERVAL SIZE                               !
!                                                             !
!      3 : CONVERT ABS. FREQ. INTO REL. FREQ.                 !
!                                                             !
!      4 : CHANGE LOWER LIMIT OF FIRST LGT. GROUP             !
!                                                             !
!      5 : ADJUST FOR SELECTION                               !
!                                                             !
!      6 : ESTIMATE WEIGHT OF SAMPLE USING W = A*L^B          !
!                                                             !
!      7 : Continue with another file                         !
!                                                             !
!      8 : QUIT (return to main menu)                         !
!                                                             !
!      Choose option  ! 1 !                                   !
!                                                             !
---------------------------- SD 1 -----------------------------
```

```
---------------------------- SD 2 -----------------------------
!                                                             !
!          GIVE WEIGHTING FACTORS                             !
!                                                             !
!                        (Return : Weighting factor = 1.00)   !
!   s    year    month    day   weighting factor              !
!  ------------------------------------------                 !
!   1    1985     APR      2       !RETURN!                   !
!   2    1985     APR      3       !RETURN!                   !
!   3    1985     APR      4       !RETURN!                   !
!   4    1985     APR      5       !RETURN!                   !
!   5    1985     APR      6       !RETURN!                   !
!                                                             !
!   Is input ok ? (y/n) default = y  !RETURN!                 !
!                                                             !
---------------------------- SD 2 -----------------------------
```

```
---------------------------- SD 3 -----------------------------
!                                                             !
!  Do you want a listing of the summed frequencies  (y/n)     !
!                                          default = n ! y !  !
!                                                             !
---------------------------- SD 3 -----------------------------
```

SD 4

SUM OF FREQUENCIES

s	year	month	day	weighting factor
1	1985	APR	2	1
2	1985	APR	3	1
3	1985	APR	4	1
4	1985	APR	5	1
5	1985	APR	6	1

Interval	Frequency
6 - 8	109
8 -10	638
10 -12	105
12 -14	422
14 -16	1355
16 -18	1042
18 -20	692
20 -22	527
22 -24	279
24 -26	112
26 -28	31
28 -30	3
Total	5315

SD 4

The remaining options are illustrated by the printer output (produced either by LFTABLE or LFMANI) described in next section.

After execution of the data manipulation the session is terminated by SD 5.

SD 5

- - MANIPULATION OF LENGTH FREQUENCIES - -

1 : Do more data manipulations

2 : Print table (LFTABLE)

3 : Quit (return to main menu)

Choose option [2]

SD 5

3.8.4. PRINTER OUTPUT.

LFMANI produces printer output only for certain options. For the remaining options the results have to be printed by aid of program LFTABLE as explained below :

1 : CALCULATE WEIGHTED SUM OF SAMPLES
Table as SD 2 produced by LFMANI.

2 : CHANGE INTERVAL SIZE
No table from LFMANI. Output from LFTABLE shown in Table 3.8.4.1

3 : CONVERT ABS. FREQ. INTO REL. FREQ.
No table from LFMANI. Output from LFTABLE shown in Table 3.8.4.2

4 : CHANGE LOWER LIMIT OF FIRST LGT. GROUP
No table from LFMANI. Output from LFTABLE shown in Table 3.8.4.3

5 : ADJUSTMENT FOR SELECTION
Output from LFTABLE shown in Table 3.8.4.4.a.
Output from LFMANI shown in Table 3.8.4.4.b.

6 : ESTIMATE WEIGHT OF SAMPLE USING W = A*L^B
Output from LFMANI shown in Table 3.8.4.5.

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank.

Year	1985	1985	1985	1985	1985	
Month	4	4	4	4	4	
Day	2	3	4	5	6	Total
6-10	145	153	149	147	153	747
10-14	119	91	100	114	103	527
14-18	393	429	544	491	540	2397
18-22	238	228	226	257	270	1219
22-26	64	91	73	92	71	319
26-30	9	5	5	8	7	34
Total	968	997	1097	1109	1144	5315

Table 3.8.4.1. Doubling of interval size (Example of option 2).
(output from LFTABLE)

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank.

Year	1985	1985	1985	1985	1985	
Month	4	4	4	4	4	
Day	2	3	4	5	6	Total
6- 8	2583	1805	2188	1713	2010	10299
8-10	12397	13541	11395	11542	11364	60239
10-12	1963	2106	1367	2525	1923	9884
12-14	10331	7021	7748	7755	7080	39935
14-16	22934	27182	27438	25518	24301	127373
16-18	17665	15848	22151	18756	22902	97322
18-20	14256	14042	9936	13706	13374	65314
20-22	10331	8826	10665	9468	10227	49517
22-24	5062	6720	5105	5230	4283	26400
24-26	1550	2407	1550	3066	1923	10496
26-28	930	401	456	631	524	2942
28-30	0	100	0	90	87	277
Total	100000	100000	100000	100000	100000	500000

Table 3.8.4.2. Relative frequencies (Example of option 3)
(Output from LFTABLE)

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

year	1985	1985	1985	1985	1985	
month	4	4	4	4	4	
day	2	3	4	5	6	Total
2- 4	0	0	0	0	0	0
4- 6	0	0	0	0	0	0
6- 8	25	18	24	19	23	109
8-10	120	135	125	128	130	638
10-12	19	21	15	28	22	105
12-14	100	70	85	86	81	422
14-16	222	271	301	283	278	1355
16-18	171	158	243	208	262	1042
18-20	138	140	109	152	153	692
20-22	100	88	117	105	117	527
22-24	49	67	56	58	49	279
24-26	15	24	17	34	22	112
26-28	9	4	5	7	6	31
28-30	0	1	0	1	1	2
Total	968	997	1097	1109	1144	5315

Table 3.8.4.3. Change of lower limit of first length group.
Example of option 4. (Output from LFTABLE)

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank

year	1985	1985	1985	1985	1985	
month	4	4	4	4	4	
day	2	3	4	5	6	Total
6- 8	68	49	66	52	63	298
8-10	189	213	197	202	205	1006
10-12	23	25	18	33	26	125
12-14	106	74	90	92	86	449
14-16	227	277	307	289	284	1384
16-18	172	159	245	209	264	1049
18-20	138	140	109	152	153	694
20-22	100	88	117	105	117	527
22-24	49	67	56	58	49	279
24-26	15	24	17	34	22	112
26-28	9	4	5	7	6	31
28-30	0	1	0	1	1	2
Total	1096	1121	1227	1234	1276	5953

Table 3.8.4.4.a. Adjustment for selection. Example of option 5. (Output from LFTABLE)

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank.

Sample no. 1 1985 APR 2 1985.25205
Adjustment for selection
L50% = 8 L75% = 10

j	L(j) - L(j+1)	Orig. FRQ	Adjust. FRQ	Selec. Ogive.
1	6.00 - 8.00	25.000	68.012	0.3660
2	8.00 - 10.00	120.000	189.820	0.6339
3	10.00 - 12.00	19.000	22.565	0.8386
4	12.00 - 14.00	100.000	106.150	0.9397
5	14.00 - 16.00	222.000	226.471	0.9790
6	16.00 - 18.00	171.000	172.188	0.9929
7	18.00 - 20.00	138.000	138.278	0.9976
8	20.00 - 22.00	100.000	100.792	0.9992
9	22.00 - 24.00	49.000	49.129	0.9997
10	24.00 - 26.00	15.000	15.013	0.9999
11	26.00 - 28.00	9.000	9.002	0.9999
12	28.00 - 30.00	0.000	0.000	1.0000

Table 3.8.4.4.b. Details of adjustment for selection of sample no. 1. Example of option 5. (Output from LFMANI)

Rastrelliger kanagurta. April 1985. Bottom trawl. Great Bank.

Cond. factor = .01 Exponent = 3

Sample	Date	Time	Weight
1	1985 APR 2	1985.25205	48107.64
2	1985 APR 3	1985.25479	50457.47
3	1985 APR 4	1985.25753	53923.61
4	1985 APR 5	1985.26027	57171.47
5	1985 APR 6	1985.26301	57507.38
		Sum	267167.57

Table 3.8.4.5. Estimation of sample sample weight from W/L relationship. Example of option 6. (output from LFMANI).

3.8.5. CONNECTIONS TO OTHER PROGRAMS.

Manipulations of length frequencies using options 2 - 6 produce data files of the type "LENGTH FREQUENCY SAMPLE".

Option 1 produces a different type of data file, manely :

"weighted sum of length frequencies"

The two types of data file can be used as input to the following programs :

Data type : LENGTH FREQUENCY SAMPLE

LFINPUT (Length frequency data entry program)
LFINF (Length frequency additional data entry program)
LFTABLE (Length frequency table program)
LFBAR (Length frequency bar diagram program)
LFSUM (Length frequency sample summing program)
LFCONV (Length frequency data entry/conversion program)
LFMANI (Length frequency data manipulation program)
LFMERGE (Length frequency file merging program)
BHATTAC (Bhattacharya analysis program)

Data type : weighted sum of length frequencies

CCURVE (Length converted catch curve analysis)
BHZWET (Beverton & Holts Z-equation and Wetherall et. all. analysis).
JONZAL (Jones & van Zalinge analysis)
LCOHOR (Jones length converted cohort analysis).

3.9. LFMERGE.

3.9.1. PURPOSE.

The purpose of LFMERGE is to merge files of length frequencies. The files to be merged must be compatible, i.e. have the same length groupings.

3.9.2. INPUT / INPUT FILE.

Input files must be of the type "LENGTH FREQUENCY SAMPLE" created by LFINPUT or LFCONV.
As an example consider Table 3.9.2.1. The table shows the list of sample times for two files "L.SEBAE.1" and "L.SEBAE.2" (which you cam assume to be compatible). In next section it is demonstrated how to merge these two files.

File name : L.SEBAE.1

s	year	month	day	time
1	1984	OCT	3	1984.7562
2	1985	FEB	11	1985.1151
3	1985	MAY	17	1985.3753
4	1985	JUL	4	1985.5069

File name : L.SEBAE.2

s	year	month	day	time
1	1984	NOV	21	1984.8904
2	1985	MAR	15	1985.2027
3	1985	MAY	23	1985.3918
4	1985	JUN	28	1985.4904

Table 3.9.2.1. Example to illustrate LFMERGE.

3.9.3. SCREEN DIALOGUE.

SD 1 shows the last question in the directory display (like SD 3 in Section 2.5.1) which is followed by the message in SD 2. Next time you retrieve a file (SD 3) the message will show both time series (SD 4).
Pressing the RETURN-key starts the merging and after a short while the merged sample times appear in chronological order (SD 5)

```
!-------------------------- SD 1 -------------------------------!
!                  ..............                               !
!                  ..............                               !
!                 Directory list                                !
!                  ..............                               !
!                  ..............                               !
!                                                               !
!  Give name of file ('p' if you want the directory printed)    !
!                                                ! L.SEBAE.1 !  !
!-------------------------- SD 1 -------------------------------!

!-------------------------- SD 2 -------------------------------!
!    The time series contains the samples :                     !
!                                                               !
!      s   year    month   day     time                         !
!     ------------------------------------                      !
!      1   1984     OCT     3    1984.7562                      !
!      2   1985     FEB    11    1985.1151                      !
!      3   1985     MAY    17    1985.3753                      !
!      4   1985     JUL     4    1985.5069                      !
!                                              !RETURN!         !
!                                                               !
!-------------------------- SD 2 -------------------------------!

!-------------------------- SD 3 -------------------------------!
!                                                               !
!                  ..............                               !
!                  ..............                               !
!                 Directory list                                !
!                  ..............                               !
!                  ..............                               !
!                                                               !
!  Give name of file ('p' if you want the directory printed)    !
!                                                ! L.SEBAE.2 !  !
!-------------------------- SD 3 -------------------------------!

!-------------------------- SD 4 -------------------------------!
!                                                               !
!    The time series contains the samples :                     !
!                                                               !
!      s   year    month   day     time                         !
!     ------------------------------------                      !
!      1   1984     OCT     3    1984.7562                      !
!      2   1985     FEB    11    1985.1151                      !
!      3   1985     MAY    17    1985.3753                      !
!      4   1985     JUL     4    1985.5069                      !
!     ------------------------------ New samples to be merged : !
!      1   1984     NOV    21    1984.8904                      !
!      2   1985     MAR    15    1985.2027                      !
!      3   1985     MAY    23    1985.3918                      !
!      4   1985     JUN    28    1985.4904                      !
!                                              !RETURN!         !
!-------------------------- SD 4 -------------------------------!
```

```
!-------------------------- SD 5 ------------------------------!
!    After merging                                              !
!    The time series contains the samples :                     !
!                                                               !
!      s   year   month   day     time                         !
!    ------------------------------------                       !
!      1   1984    OCT     3    1984.7562                      !
!      1   1984    NOV    21    1984.8904                      !
!      2   1985    FEB    11    1985.1151                      !
!      2   1985    MAR    15    1985.2027                      !
!      3   1985    MAY    17    1985.3753                      !
!      3   1985    MAY    23    1985.3918                      !
!      4   1985    JUN    28    1985.4904                      !
!      4   1985    JUL     4    1985.5069                      !
!                                          !RETURN!            !
!-------------------------- SD 5 ------------------------------!
```

You may repeat this process as many times as you like (or until you run short of computer memory).

If you try to merge two incompatible files you will get a message like that one shown in SD 6.

```
!-------------------------- SD 6 ------------------------------!
!                                                               !
!  Give name of file ('p' if you want the directory printed)    !
!                                          ! R.KANAGURTA !      !
!                                                               !
! In the foregoing files the interval size was    1             !
! and lower limit of first length group was       1             !
!                                                               !
! In file R.KANAGURTA                                           !
! Rastrelliger kanagurta. Coconut Bay. 1978.                    !
! these parameters are :                                        !
!                          Interval size          2             !
! and lower limit of first length group was       6             !
!                                                               !
! This file cannot be merged (try another one)                  !
!-------------------------- SD 6 ------------------------------!
```

3.9.4. PRINTER OUTPUT.

LFMERGE does not produce any printer output. You can get a printed table of the merged time series using program LFTABLE.

3.9.5. CONNECTIONS TO OTHER PROGRAMS.

LFMERGE produces files of the type

LENGTH FREQUENCY SAMPLE

These files have the same status as those produced by LFINPUT or LFCONV, and LFMERGE thus has the same connections.

3.10. BHATTAC.

1. PURPOSE.

The purpose of program BHATTAC is to resolve a length frequency sample into normally distributed components using the Bhattacharya method (or the log-difference method), (Bhattacharya, 1967).

The procedure works in steps. In each step a component is indentified. The current component to be identified is always the leftmost one, which subsequently is subtracted from the remaining part of the frequency distribution. The frequencies remaining after subtraction of the leftmost component form the input to the next step.

The present method requires the user to monitor the estimation process and to take a number of key decisions on the calculations.
The method may be said to be a computerized version of the "paper and pencil method".
Thus, this is not an "objective" method. The results obtained may depend on the person who runs the program.

3.10.2. INPUT / INPUT FILE.

Input data must be of the type :

"LENGTH FREQUENCY SAMPLE"

i.e. created by LFINPUT/LFCONV or it may have been created during an earlier run with BHATTAC, in which case the type is :

"LENGTH FREQUENCY SAMPLE BHAT"

As the Bhattacharya method works with logarithms of frequencies the length interval size should be chosen so that zero observations between non-zero observations become rare. The program will not break down because of zero frequencies, but they may obscure the method.

To illustrate the program a time series of four length frequency samples is used. The frequencies are shown in Table 3.10.2.1, and the bar diagram corresponding to the first sample is shown in Figure 3.10.2.1.
The data in Table 3.10.2.1 are hypothetical data, and therefore they "behave better" than most data from real life.

The example of Table 3.10.2.1 is used to illustrate all the programs dealing with processing (parameter estimation) of length frequency data.
To illustrate BHATTAC, however, we use only the first sample (Figure 3.10.2.1).

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

year	1985	1985	1985	1986	
month	4	7	10	1	
day	4	7	15	10	Total
6.0- 6.5	1	0	0	0	1
6.5- 7.0	6	0	0	0	6
7.0- 7.5	23	0	0	0	23
7.5- 8.0	67	1	0	0	68
8.0- 8.5	134	7	0	0	141
8.5- 9.0	190	24	0	0	214
9.0- 9.5	193	65	3	0	261
9.5-10.0	139	138	12	1	290
10.0-10.5	71	230	33	3	337
10.5-11.0	27	305	78	11	421
11.0-11.5	11	321	153	29	514
11.5-12.0	14	267	253	65	599
12.0-12.5	31	179	350	127	687
12.5-13.0	65	103	406	212	786
13.0-13.5	118	67	396	306	887
13.5-14.0	189	70	329	381	969
14.0-14.5	266	104	242	413	1025
14.5-15.0	332	155	173	392	1052
15.0-15.5	369	213	144	333	1059
15.5-16.0	368	265	150	264	1047
16.0-16.5	334	300	178	210	1022
16.5-17.0	284	310	211	183	988
17.0-17.5	236	296	236	180	948
17.5-18.0	202	267	247	188	904
18.0-18.5	182	232	242	198	854
18.5-19.0	174	199	225	201	799
19.0-19.5	170	174	201	195	740
19.5-20.0	164	156	176	181	677
20.0-20.5	154	143	153	162	612
20.5-21.0	141	131	133	141	546
21.0-21.5	124	119	116	122	481
21.5-22.0	107	105	102	104	418
22.0-22.5	91	91	88	88	358
22.5-23.0	76	77	75	74	302
23.0-23.5	62	63	63	62	250
23.5-24.0	50	51	51	50	202
24.0-24.5	40	40	40	40	160
24.5-25.0	31	31	31	31	124
25.0-25.5	24	24	24	24	96
25.5-26.0	17	17	17	17	68
26.0-26.5	12	12	12	12	48
26.5-27.0	9	9	9	9	36
27.0-27.5	6	6	6	6	24
27.5-28.0	4	4	4	4	16
28.0-28.5	2	2	2	2	8
28.5-29.0	1	1	1	1	4
Total	5311	5374	5365	5022	21072

Table 3.10.2.1. Input data to BHATTAC. (Hypothetical data). The table is produced using the program LFTABLE. Only the first sample (cf. Figure 3.10.2.1) is used to demonstrate BHATTAC.

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

4. APR 1985 time : 1985.25753
Total sample size : 5311 Max freq. : 369

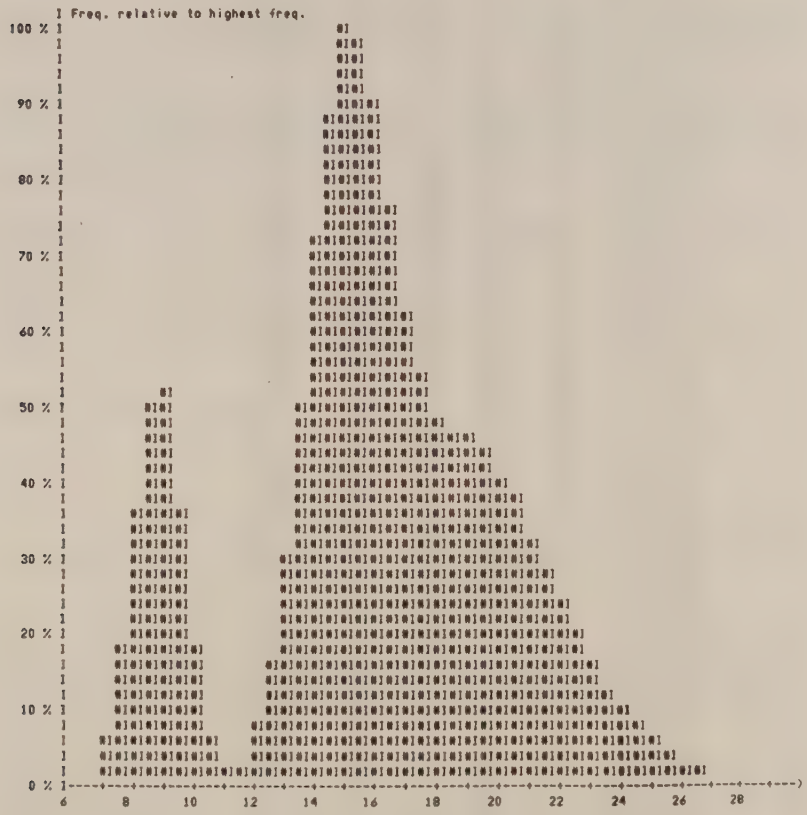


Figure 3.10.2.1. Input data to BHATTAC. (Hypothetical data).
The diagram is produced using the program LFBAR.

Figure 3.10.2.2 shows the same length frequency sample as Figure 3.10.2.1, but adjusted for selection. In this case the calculations were made using program LFMANI, option 5, with L50% = 13 and L75% = 15. However, as will be demonstrated in the next section, these calculation can be made by BHATTAC as well.

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

4. APR 1985 time : 1985.25753
Total sample size : 16239 Max freq. : 2440

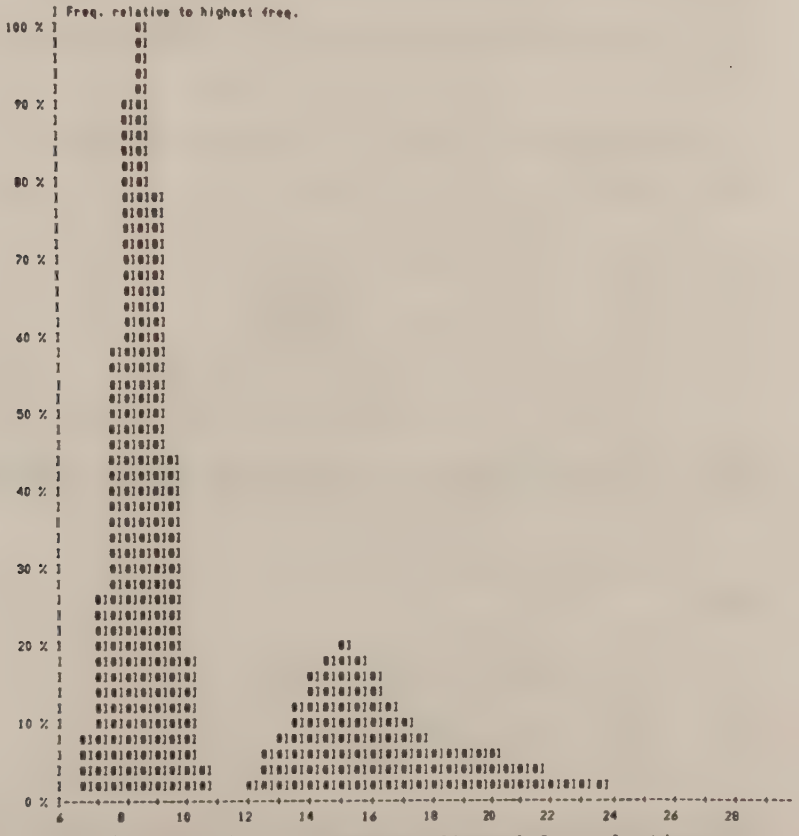


Figure 3.10.2.2. Input data to BHATTAC adjusted for selection. (Calculated using program LFMANI). (Hypothetical data). The diagram is produced using the program LFBAR.

3.10.3. SCREEN DIALOGUE.

After retrieval of the input data file the message and the prompt in SD 1 appears.

SD 1 offers you the option to adjust for selection.

The way of adjusting for selection in BHATTAC is exactly the same as the one used by LFMANI (Option 5). You could as well have adjusted for selection using LFMANI (cf. Figure 3.10.2.2).

The option is included in BHATTAC to make it easier to run a series of Bhattacharya analyses based on alternative assumptions on selection.

```
---------------------------- SD 1 -------------------------------
!                                                               !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay      !
!                                                               !
! The time series contains the samples :                        !
!                                                               !
!                                                               !
!    s   year    month    day     time                         !
!  ---------------------------------------                      !
!    1   1985      APR      4    1985.2575                      !
!    2   1985      JUL      7    1985.5151                      !
!    3   1985      OCT     15    1985.7890                      !
!    4   1986      JAN     10    1985.0274                      !
!                                                               !
! Do you want to adjust for selection (y/n)  default = n  I y I !
!                                                               !
---------------------------- SD 1 -------------------------------
```

If you want to adjust for selection SD 2 follows, where you enter the parameters necessary for the construction of the selection ogive (cf. the manual to LFMANI) :

$$S(Li) = 1/(1+\exp(s1-s2*Li))$$

where

S(Li) = fraction selected,

Li = midpoint of length class no. i,

s2 = log(3)/(L75%-L50%) , s1 = L50%*s2

L50% and L75% are the 50 % and 75 % selection lengths respectively.

The frequencies are adjusted by replacing the frequency, FRQ by the adjusted frequency, FRQ/S.

```
---------------------------- SD 2 -------------------------------
!                                                               !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay      !
!                                                               !
!  Lower limit of first length group   6                        !
!  Upper limit of last length group   29.5                      !
!  Interval size                       0.5                      !
!                                                               !
!  Selection parameters :                                       !
!                                                               !
!  Give  L50%      ! 13 !                                       !
!                                                               !
!  Give  L75%      ! 15 !                                       !
!                                                               !
!  Is input ok ? (y/n) ? default = y  !RETURN!                  !
!                                                               !
! Do you want to see the adjusted samples (y/n)                 !
!                                      default = n    ! y !     !
!                                                               !
---------------------------- SD 2 -------------------------------
```

All samples in the time series will be corrected with the same selection ogive (i.e. the same selection parameters).

In the last line of SD 2 you are offered the option to look at the details of the adjustment process. If you answer yes, the result becomes SD 3.

As there are four samples in the file three more screen displays like SD 3 will be shown.

The result of the adjustment for selection can be further assessed by comparing Figures 3.10.2.1 and 3.10.2.2.

Having completed the adjustment for selection you are asked to select a sample in SD 4.

```
---------------------------- SD 4 -------------------------------
!                                                               !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay      !
!                                                               !
! The time series contain the samples :                         !
!                                                               !
!    s   year     month     day      time                       !
!  ---------------------------------------                      !
!    1   1985      APR       4     1985.2575                    !
!    2   1985      JUL       7     1985.5151                    !
!    3   1985      OCT      15     1985.7890                    !
!    4   1986      JAN      10     1986.0274                    !
!                                                               !
!   Give number of sample to be analysed  ! 1 !                 !
!                                                               !
---------------------------- SD 4 -------------------------------
```

SD 3

Sample no. 1 1985 APR 4
Adjustment for selection
L50% = 13 L75% = 15

j	L(j) - L(j+1)	Orig. FRQ	Adjust. FRQ	Selec. Ogive
1	6.000- 6.500	1.000	41.647	0.02394
2	6.500- 7.000	6.000	191.468	0.03127
3	7.000- 7.500	23.000	564.167	0.04075
4	7.500- 8.000	67.000	1265.690	0.05295
5	8.000- 8.500	134.000	1954.232	0.06854
6	8.500- 9.000	190.000	2151.166	0.08830
7	9.000- 9.500	193.000	1707.177	0.11305
8	9.500- 10.000	139.000	967.845	0.14365
9	10.000- 10.500	71.000	392.881	0.18085
10	10.500- 11.000	27.000	119.234	0.22514
11	11.000- 11.500	11.000	39.656	0.27662
12	11.500- 12.000	14.000	41.181	0.33478
13	12.000- 12.500	31.000	77.039	0.39843
14	12.500- 13.000	65.000	139.681	0.46572
15	13.000- 13.500	118.000	220.589	0.53427
16	13.500- 14.000	189.000	314.818	0.60156
17	14.000- 14.500	266.000	399.692	0.66521
18	14.500- 15.000	332.000	458.571	0.72338
19	15.000- 15.500	369.000	476.173	0.77485
20	15.500- 16.000	368.000	449.467	0.81914
21	16.000- 16.500	334.000	390.305	0.85634
22	16.500- 17.000	284.000	320.006	0.88694
23	17.000- 17.500	236.000	258.575	0.91169
24	17.500- 18.000	202.000	216.658	0.93145
25	18.000- 18.500	182.000	192.772	0.94704
26	18.500- 19.000	174.000	181.930	0.95924
27	19.000- 19.500	170.000	175.884	0.96872
28	19.500- 20.000	164.000	168.230	0.97605
29	20.000- 20.500	154.000	156.705	0.98170
30	20.500- 21.000	141.000	142.969	0.98603
31	21.000- 21.500	124.000	125.344	0.98935
32	21.500- 22.000	107.000	107.749	0.99189
33	22.000- 22.500	91.000	91.654	0.99382
34	22.500- 23.000	76.000	76.588	0.99530
35	23.000- 23.500	62.000	62.224	0.99642
36	23.500- 24.000	50.000	50.362	0.99728
37	24.000- 24.500	40.000	40.828	0.99793
38	24.500- 25.000	31.000	31.487	0.99842
39	25.000- 25.500	24.000	24.287	0.99880
40	25.500- 26.000	17.000	17.154	0.99909
41	26.000- 26.500	12.000	12.082	0.99931
42	26.500- 27.000	9.000	9.047	0.99947
43	27.000- 27.500	6.000	6.024	0.99960
44	27.500- 28.000	4.000	4.012	0.99969
45	28.000- 28.500	2.000	2.004	0.99977
46	28.500- 29.000	1.000	1.001	0.99982

Do you want the table printed (y/n) default = n !RETURN!

SD 3

The Bhattacharya analysis is an analysis of a single length frequency sample. The result of the analysis of one sample is independent of the results from other samples. You may analyse the samples in any sequence and you may analyse any subset of the time series you like.
In this example we start by selecting sample no. 1 (cf. SD 4), and then follows the menu in SD 5

```
----------------------------- SD 5 -----------------------------
!                                                              !
!            - - BHATTACHARYA ANALYSIS - -                     !
!                                                              !
! 1 : See Bhattacharya plot and select points                  !
!                                                              !
! 2 : Print table of input for Bhattacharya plot on screen     !
!                                                              !
! 3 : Print table of input for Bhattacharya plot on printer    !
!                                                              !
! 4 : Start calculations                                       !
!                                                              !
! 5 : See earlier results                                      !
!                                                              !
! 6 : Quit (and save results)                                  !
!                                                              !
!  (Option 1 must be executed before option 4)                 !
!                                                              !
!    Choose option (default = 1)  ! 2 !                        !
!                                                              !
----------------------------- SD 5 -----------------------------
```

To illustrate the calculation procedure we start by selecting option 2. The result is shown in SD 6.
The table in SD 6 is the numerical counterpart to the graph produced by the default option in SD 5 , i.e. option 1. The default option produces the Bhattacharya plot shown in SD 7. To explain the graph let us call the horizontal axis the X-axis and the vertical axis the Y-axis.

X and Y are defined :

index of length group j = X	lower limit of length group L(j)	log-difference Y(j)
1	LF	0
2	LF+dL	log FRQ(s,2) - log FRQ(s,1)
3	LF+2*dL	log FRQ(s,3) - log FRQ(s,2)
4	LF+3*dL	log FRQ(s,4) - log FRQ(s,3)
:	:	:
j	LF+(j-1)*dL	log FRQ(s,j) - log FRQ(s,j-1)
:	:	:

where LF = lower limit of first length group
dL = length interval size.

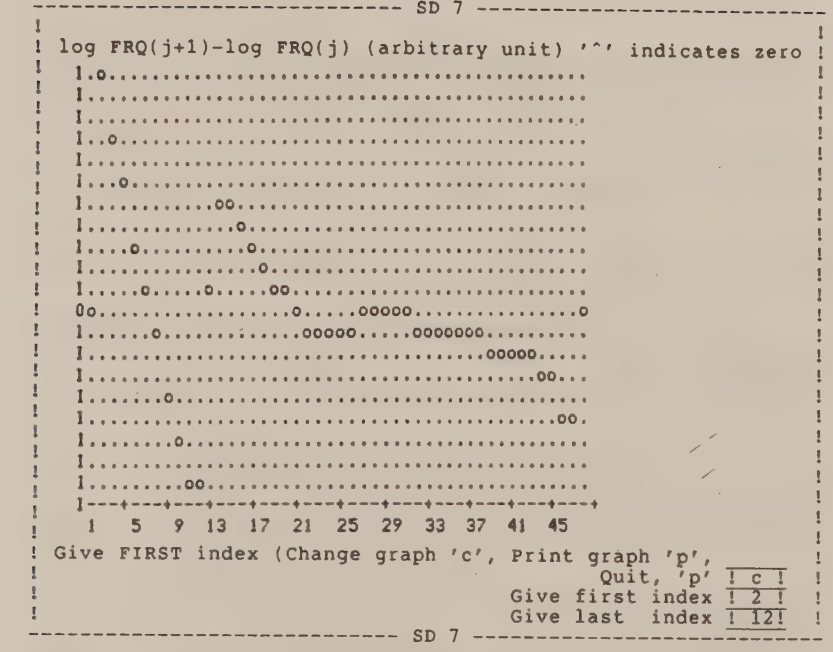
SD 6

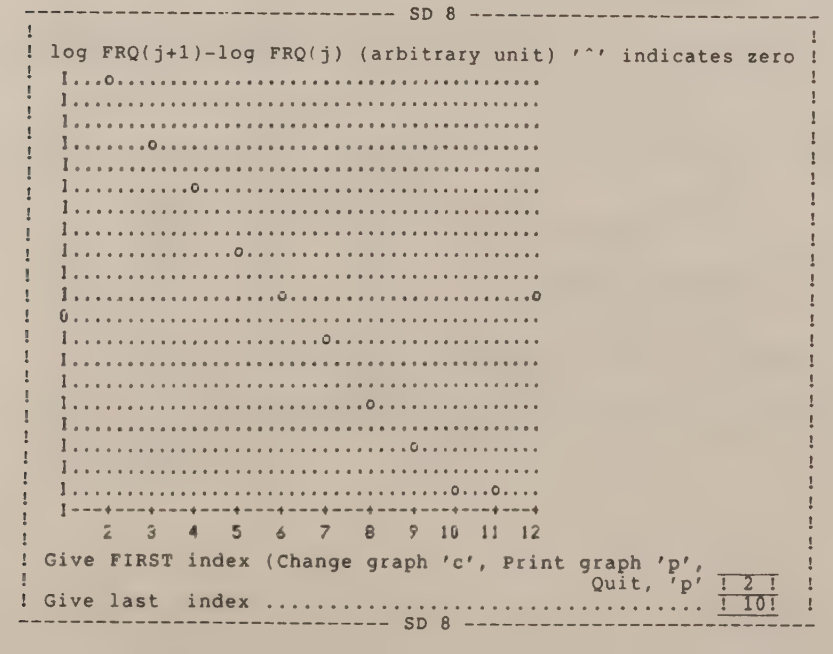
Nemipterus marginatus. Research Trawl Survey. Manila Bay

Sample no. 1 1985 APR 4 1985.25753

j	L(j) - L(j+1)	FRQ(j)	Log(FRQ(j))	D Log(FRQ(j,j+1))
1	6.000- 6.500	42	3.7320	0.0000
2	6.500- 7.000	192	5.2566	1.5246
3	7.000- 7.500	564	6.3356	1.0789
4	7.500- 8.000	1265	7.1429	0.8073
5	8.000- 8.500	1955	7.5780	0.4350
6	8.500- 9.000	2152	7.6740	0.0959
7	9.000- 9.500	1707	7.4425	-0.2314
8	9.500- 10.000	968	6.8748	-0.5677
9	10.000- 10.500	393	5.9727	-0.9020
10	10.500- 11.000	120	4.7868	-1.1859
11	11.000- 11.500	40	3.6830	-1.1038
12	11.500- 12.000	42	3.7333	0.0503
13	12.000- 12.500	78	4.3541	0.6208
14	12.500- 13.000	140	4.9385	0.5843
15	13.000- 13.500	221	5.3975	0.4589
16	13.500- 14.000	314	5.7499	0.3524
17	14.000- 14.500	400	5.9911	0.2411
18	14.500- 15.000	459	6.1289	0.1378
19	15.000- 15.500	476	6.1658	0.0369
20	15.500- 16.000	449	6.1075	-0.0583
21	16.000- 16.500	390	5.9662	-0.1413
22	16.500- 17.000	320	5.7689	-0.1972
23	17.000- 17.500	259	5.5562	-0.2126
24	17.500- 18.000	217	5.3792	-0.1769
25	18.000- 18.500	192	5.2584	-0.1208
26	18.500- 19.000	181	5.2006	-0.0577
27	19.000- 19.500	175	5.1675	-0.0330
28	19.500- 20.000	168	5.1241	-0.0434
29	20.000- 20.500	157	5.0554	-0.0686
30	20.500- 21.000	143	4.9628	-0.0925
31	21.000- 21.500	125	4.8309	-0.1318
32	21.500- 22.000	108	4.6809	-0.1500
33	22.000- 22.500	92	4.5170	-0.1639
34	22.500- 23.000	76	4.3354	-0.1816
35	23.000- 23.500	62	4.1307	-0.2047
36	23.500- 24.000	50	3.9147	-0.2159
37	24.000- 24.500	40	3.6909	-0.2237
38	24.500- 25.000	31	3.4355	-0.2553
39	25.000- 25.500	24	3.1792	-0.2563
40	25.500- 26.000	17	2.8341	-0.3451
41	26.000- 26.500	12	2.4855	-0.3485
42	26.500- 27.000	9	2.1977	-0.2878
43	27.000- 27.500	6	1.7921	-0.4055
44	27.500- 28.000	4	1.3865	-0.4055
45	28.000- 28.500	2	0.6933	-0.6932
46	28.500- 29.000	1	0.0001	-0.6932

SD 6


SD 7
log FRQ(j+1)-log FRQ(j) (arbitrary unit) '^' indicates zero
1 5 9 13 17 21 25 29 33 37 41 45
Give FIRST index (Change graph 'c', Print graph 'p',
Quit, 'p' ! c !
Give first index ! 2 !
Give last index ! 12!
SD 7


SD 8
log FRQ(j+1)-log FRQ(j) (arbitrary unit) '^' indicates zero
2 3 4 5 6 7 8 9 10 11 12
Give FIRST index (Change graph 'c', Print graph 'p',
Quit, 'p' ! 2 !
Give last index ..... ! 10!
SD 8

The graph is rescaled so that the Ys become :

$$20*(Y(j) - Ymin) / (Ymax - Ymin)$$

where Ymax and Ymin are the maximum and the minimum Y-values respectively.
The figure "20" reflects the number of available lines on the screen.

The Xs are rescaled in a similar way. Notice that the values on the X-axis are the indices, j, of length groups, not the lengths (the indices are shown in SD 6).

The next step in the procedure must be done by the user, namely to identify a sequence of points conforming to a straight line with negative slope.
In SD 7 it is relatively easy to see that points 2-10 conform to a straight line.

However, often it is difficult to assess the graph (partly because of the crude resolution) and therefore BHATTAC offers an option to "zoom" on a smaller part of the graph.
You zoom by selecting option 'c' in SD 7 and then in the next two lines indicate the part of the graph you want to enlarge. The result is shown in SD 8.

In the two last lines in SD 8 the points conforming to the straight line are selected.

The following display (SD 9) is nearly identical to SD 5 except that the default option is now 4.

```
------------------------------ SD 9 ------------------------------
!                                                                !
!            - - BHATTACHARYA ANALYSIS - -                       !
!                                                                !
! 1 : See Bhattacharya plot and select points                    !
!                                                                !
! 2 : Print table of input for Bhattacharya plot on screen       !
!                                                                !
! 3 : Print table of input for Bhattacharya plot on printer      !
!                                                                !
! 4 : Start calculations                                         !
!                                                                !
! 5 : See earlier results                                        !
!                                                                !
! 6 : Quit (and save results)                                    !
!                                                                !
!  (Option 1 must be executed before option 4)                   !
!                                                                !
!    Choose option (default = 4)  !RETURN!                       !
!                                                                !
------------------------------ SD 9 ------------------------------
```

Selecting the default option produces the basic results of the first regression analysis, i.e. the analysis which is used to estimate :

Mean length of the component (or cohort)

Standard deviation of the length distribution.

Number of cohort members in the sample

```
------------------------------ SD 10 ------------------------------
!                                                                  !
! Nemipterus marginatus. Research Trawl Survey. Manila bay.        !
!                                                                  !
!  a  n   Interval   Mean-L     S      N     Cal.N   S.I.  Index   !
! ---------------------------------------------------------------- !
!  1  9  6.50-11.00   8.674  0.861  9386    9387           (2-10)  !
!                                                                  !
!   Adjusted for selection    L50% = 13   L75% = 15                !
!                                                                  !
!  a      : Component (cohort) no.                                 !
!  n      : Number of observations used to estimate component      !
!  S      : Standard deviation                                     !
!  N      : Number in cohort 'observed'                            !
!  Cal.N  : Calculated number in cohort                            !
!  S.I.   : 2*(MeanL(a)-MeanL(a-1))/(S(a-1)+S(a))                  !
!  Index  : Indices used in regression                             !
!                                                      !RETURN!    !
------------------------------ SD 10 ------------------------------
```

To explain the actual calculations, let j1 and j2 be the two selected points (or indices) from SD 8.
From the regression of Y(j) on L(j) (for j = j1,...,j2) the intercept and the slope are calculated which in turn give :

$$Lmean = - \text{intercept/slope} \quad \text{and} \quad S = \sqrt{- dL/\text{slope}}$$

Next step is to calculate the numbers by length group for the cohort. We start by calculating :

$$G(j) = \frac{dL}{\sqrt{2pi}\ S} \exp\left(-0.5*((L(j)+dL/2 - Lmean) / S)^2\right)$$

from which the estimate of the total cohort number is derived

$$Cal.N = \sum_j FRQ(s,j) \Big/ \sum_j G(j)$$

SD 10 is followed by the menu in SD 11. If option 7 in SD 11 is chosen more details on the calculations are displayed, as shown in SD 12.

```
---------------------------- SD 11 ----------------------------
!                                                              !
!           - - BHATTACHARYA ANALYSIS - -                      !
!                                                              !
!   1 : Redo Calculations for component no. 1                  !
!   2 : Redo calc. for sample no. 1 (all components)           !
!   3 : Search for more components in sample no. 1             !
!       ========================================               !
!   4 : Quit sample no. 1 (and continue with another sample)   !
!   5 : Print basic results on screen for sample no. 1         !
!   6 : Print basic results on printer for sample no. 1        !
!   7 : Print table of numbers on screen                       !
!   8 : Print table of numbers on printer                      !
!   9 : Print details of regression analysis on screen         !
!  10 : Print details of regression analysis on printer        !
!  11 : Quit analysis (print and save results)                 !
!                                                              !
!    Choose option (default = 3)  ! 7 !                        !
!                                                              !
---------------------------- SD 11 ----------------------------
```

The symbol FRQ(Na+) stands for the "initial frequencies", i.e. the fish in the sample from cohort no. a and older fish (the "a+ group").

The column "FRQ(Na)" contains the estimated number in the cohort by length group :

For indices j < j2 : FRQ(Na) = FRQ(Na+)

For indices j > j2 : FRQ(Na) = min (FRQ(Na+) , cal.FRQ(Na))
where cal.FRQ(Na) = cal.N * G(j)

The indices, j1,j1+1,...,j2, used in the regression analysis are marked by "used" in SD 12.

The last column "FRQ(N(a+1)+) gives the frequencies after subtraction :

$$FRQ(N(a+1)+) = FRQ(Na+) - FRQ(Na)$$

These are the input data for the next regression analysis (compare SD 17).

SD 12

Component no. (a=) 1

j	L(j) - L(j+1)		FRQ(Na+)	FRQ(Na)	cal.FRQ(Na)	FRQ(N(a+1)+)	
1	6.000-	6.500	41.76	41.76	41.55	0.00	
2	6.500-	7.000	191.84	191.84	179.64	0.00	used
3	7.000-	7.500	564.31	564.31	554.61	0.00	used
4	7.500-	8.000	1265.17	1265.17	1222.77	0.00	used
5	8.000-	8.500	1954.82	1954.82	1925.17	0.00	used
6	8.500-	9.000	2151.71	2151.71	2164.55	0.00	used
7	9.000-	9.500	1707.11	1707.11	1737.97	0.00	used
8	9.500-	10.000	967.58	967.58	996.53	0.00	used
9	10.000-	10.500	392.58	392.58	408.04	0.00	used
10	10.500-	11.000	119.92	119.92	119.31	0.00	used
11	11.000-	11.500	39.76	24.91	24.91	14.85	
12	11.500-	12.000	41.81	3.71	3.71	38.10	
13	12.000-	12.500	77.80	0.39	0.39	77.40	
14	12.500-	13.000	139.56	0.00	0.00	139.56	
15	13.000-	13.500	220.85	0.00	0.00	220.85	
16	13.500-	14.000	314.18	0.00	0.00	314.18	
17	14.000-	14.500	399.87	0.00	0.00	399.87	
18	14.500-	15.000	458.95	0.00	0.00	458.95	
19	15.000-	15.500	476.21	0.00	0.00	476.21	
20	15.500-	16.000	449.24	0.00	0.00	449.24	
21	16.000-	16.500	390.03	0.00	0.00	390.03	
22	16.500-	17.000	320.20	0.00	0.00	320.20	
23	17.000-	17.500	258.85	0.00	0.00	258.85	
24	17.500-	18.000	216.86	0.00	0.00	216.86	
25	18.000-	18.500	192.17	0.00	0.00	192.17	
26	18.500-	19.000	181.39	0.00	0.00	181.39	
27	19.000-	19.500	175.48	0.00	0.00	175.48	
28	19.500-	20.000	168.02	0.00	0.00	168.02	
29	20.000-	20.500	156.87	0.00	0.00	156.87	
30	20.500-	21.000	142.99	0.00	0.00	142.99	
31	21.000-	21.500	125.33	0.00	0.00	125.33	
32	21.500-	22.000	107.87	0.00	0.00	107.87	
33	22.000-	22.500	91.56	0.00	0.00	91.56	
34	22.500-	23.000	76.35	0.00	0.00	76.35	
35	23.000-	23.500	62.22	0.00	0.00	62.22	
36	23.500-	24.000	50.13	0.00	0.00	50.13	
37	24.000-	24.500	40.08	0.00	0.00	40.08	
38	24.500-	25.000	31.04	0.00	0.00	31.04	
39	25.000-	25.500	24.02	0.00	0.00	24.02	
40	25.500-	26.000	17.01	0.00	0.00	17.01	
41	26.000-	26.500	12.00	0.00	0.00	12.00	
42	26.500-	27.000	9.00	0.00	0.00	9.00	
43	27.000-	27.500	6.00	0.00	0.00	6.00	
44	27.500-	28.000	4.00	0.00	0.00	4.00	
45	28.000-	28.500	2.00	0.00	0.00	2.00	
46	28.500-	29.000	1.00	0.00	0.00	1.00	

SD 12

```
---------------------------- SD 13 ----------------------------
!                                                             !
!    RESULTS OF THE REGRESSION ANALYSIS                       !
!                                                             !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay    !
!                                                             !
! Number of observations  9                                   !
!                                                             !
!                                                             !
!     Intercept  a            5.84105963                      !
!     std. dev. of intercept  .0812292821                     !
!     Confidence interval of intercept 5.64854623 - 6.03357303!
!                                                             !
!     Slope      b            -.673395226                     !
!     std. dev. of slope      9.44803358E-03                  !
!     Confidence interval of slope     -.695787065 - -.651003386!
!                                                             !
!     Mean value of x's       8.5                             !
!     Std. dev. of x's        1.36930639                      !
!     Mean value of y's       .117200212                      !
!     Std. dev. of y's        .922719474                      !
!                                                             !
!     Correlation coeff.  r   -.999311724                     !
!                         r*r .998623922                      !
!     Confidence interval of r         -.999861048 - -.996594443!
!                                                             !
!                                                             !
!                                                             !
---------------------------- SD 13 ----------------------------
```

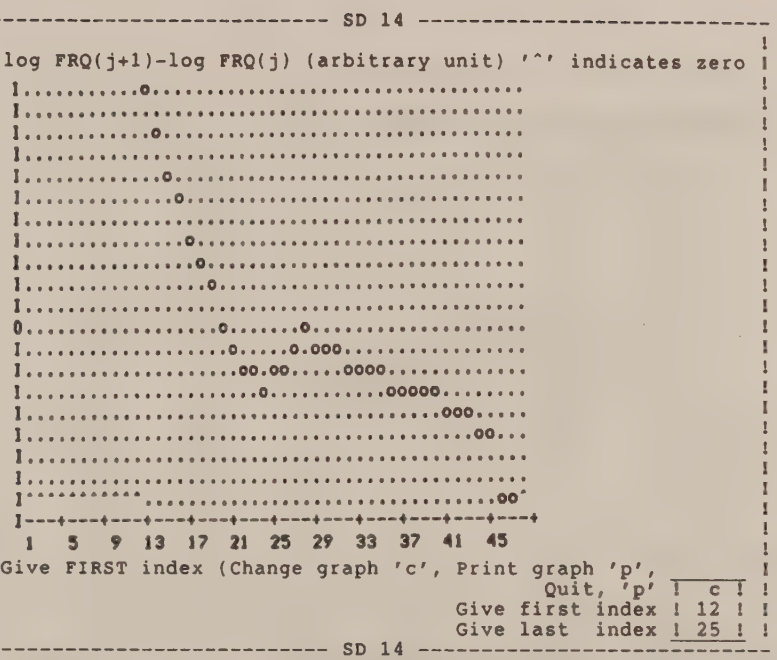
Option 9 in SD 11 produces SD 13, which is the standard result table of linear regression analysis used in all programs of the FSA package.
There is no immediate use of the these results and usually they are ignored.

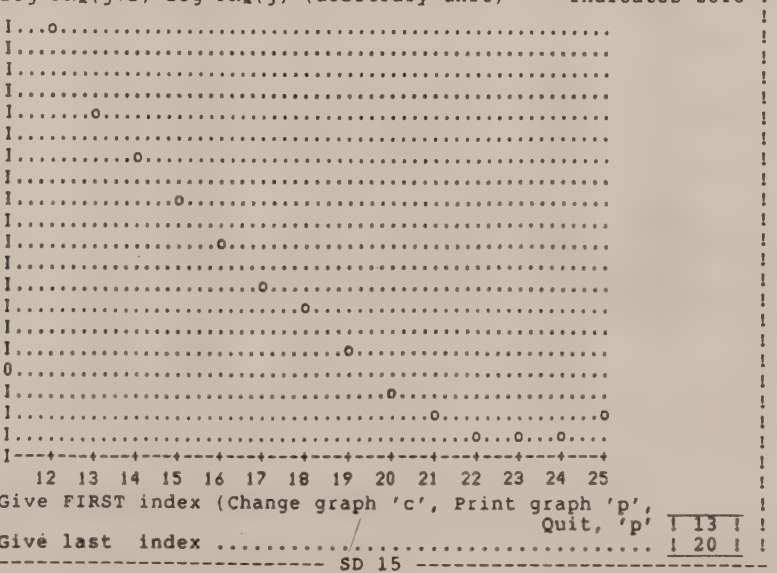
Selecting the default option (3) in SD 11 makes SD 5 reappear. The following steps become a repetition of what was done to find the first cohort.

The first cohort has now been removed and we start from scratch with the right most column of SD 12 as input.

Selecting the default option in SD 5 produces SD 14.

As was the case in SD 7 a part of the graph in SD 14 is enlarged to get the graph shown in SD 15, where the selection of the points on a straight line is made. The results for the second cohort are shown in SD 16.


SD 14
log FRQ(j+1)-log FRQ(j) (arbitrary unit) '^' indicates zero
1 5 9 13 17 21 25 29 33 37 41 45
Give FIRST index (Change graph 'c', Print graph 'p', Quit, 'p' c
Give first index 12
Give last index 25
SD 14


SD 15
log FRQ(j+1)-log FRQ(j) (arbitrary unit) '^' indicates zero
12 13 14 15 16 17 18 19 20 21 22 23 24 25
Give FIRST index (Change graph 'c', Print graph 'p', Quit, 'p' 13
Give last index 20
SD 15

```
------------------------------ SD 16 -----------------------------
!                                                                !
! Nemipterus marginatus. Research Trawl Survey. Manila bay.      !
!                                                                !
!  a  n   Interval   Mean-L     S     N    Cal.N   S.I.  Index   !
! ---------------------------------------------------------------!
!  1  9  6.50-11.00   8.674  0.861  9386   9387          (2-10)  !
!  2  8 12.00-16.00  15.156  1.510  3635   3639    5.466 (13-20) !
!                                                                !
!  Adjusted for selection    L50% = 13   L75% = 15               !
!                                                                !
!  a     : Component (cohort) no.                                !
!  n     : Number of observations used to estimate component     !
!  S     : Standard deviation                                    !
!  N     : Number in cohort 'observed'                           !
!  Cal.N : Calculated number in cohort                           !
!  S.I.  : 2*(MeanL(a)-MeanL(a-1))/(S(a-1)+S(a))                 !
!  Index : Indices used in regression                            !
!                                                  !RETURN!      !
!                                                                !
------------------------------ SD 16 -----------------------------
```

SD 16 is similar to SD 10 except that one more line has been added to the table.

SD 16 is followed by SD 11 from which option 7 produces SD 17.

Comparing SD 12 and SD 17 shows how FRQ(N(a+1)+) (the (a+1) plus group) of the foregoing regression analysis becomes an input to the current analysis.

The quantity S.I. (Separation Index) is used to indicate when to stop the procedure (as explained in Hasselblad, 1966). If S.I. < 2 it is time to stop and you will get a message when it happens.

SD 18 shows the basic results after the fourth cohort has been found. At this stage you may stop and either continue with another sample or terminate the run be saving the results on disk.

To quit the analysis (e.g. after having analysed all four samples) you choose option 6 in SD 5 or option 11 in SD 11.

If is possible to analyse a part of the samples one day and complete the job some other day.
To see what has been done earlier, you should select option 5 in SD 5, which produces a screen display similar to SD 16 (but with some table entries missing as not all results are saved). See example in SD 19.

SD 17

Component no. (a=) 2

j	L(j) - L(j+1)		FRQ(Na+)	FRQ(Na)	cal.FRQ(Na)	FRQ(N(a+1)+)	
1	6.000-	6.500	0.00	0.00	0.00	0.00	
2	6.500-	7.000	0.00	0.00	0.00	0.00	
3	7.000-	7.500	0.00	0.00	0.00	0.00	
4	7.500-	8.000	0.00	0.00	0.00	0.00	
5	8.000-	8.500	0.00	0.00	0.00	0.00	
6	8.500-	9.000	0.00	0.00	0.05	0.00	
7	9.000-	9.500	0.00	0.00	0.22	0.00	
8	9.500-	10.000	0.00	0.00	0.79	0.00	
9	10.000-	10.500	0.00	0.00	2.45	0.00	
10	10.500-	11.000	0.00	0.00	6.80	0.00	
11	11.000-	11.500	14.85	14.85	16.93	0.00	
12	11.500-	12.000	38.10	38.10	37.74	0.00	
13	12.000-	12.500	77.40	77.40	75.40	0.00	used
14	12.500-	13.000	139.56	139.56	134.99	0.00	used
15	13.000-	13.500	220.85	220.85	216.60	0.00	used
16	13.500-	14.000	314.18	314.18	311.46	0.00	used
17	14.000-	14.500	399.87	399.87	401.37	0.00	used
18	14.500-	15.000	458.95	458.95	463.54	0.00	used
19	15.000-	15.500	476.21	476.21	479.75	0.00	used
20	15.500-	16.000	449.24	449.24	444.99	0.00	used
21	16.000-	16.500	390.03	369.89	369.89	20.14	
22	16.500-	17.000	320.20	275.55	275.55	44.65	
23	17.000-	17.500	258.85	183.96	183.96	74.89	
24	17.500-	18.000	216.86	110.06	110.06	106.80	
25	18.000-	18.500	192.17	59.01	59.01	133.16	
26	18.500-	19.000	181.39	28.35	28.35	153.04	
27	19.000-	19.500	175.48	12.21	12.21	163.27	
28	19.500-	20.000	168.02	4.71	4.71	163.31	
29	20.000-	20.500	156.87	1.63	1.63	155.24	
30	20.500-	21.000	142.99	0.50	0.50	142.49	
31	21.000-	21.500	125.33	0.14	0.14	125.19	
32	21.500-	22.000	107.87	0.03	0.03	107.84	
33	22.000-	22.500	91.56	0.00	0.00	91.56	
34	22.500-	23.000	76.35	0.00	0.00	76.35	
35	23.000-	23.500	62.22	0.00	0.00	62.22	
36	23.500-	24.000	50.13	0.00	0.00	50.13	
37	24.000-	24.500	40.08	0.00	0.00	40.08	
38	24.500-	25.000	31.04	0.00	0.00	31.04	
39	25.000-	25.500	24.02	0.00	0.00	24.02	
40	25.500-	26.000	17.01	0.00	0.00	17.01	
41	26.000-	26.500	12.00	0.00	0.00	12.00	
42	26.500-	27.000	9.00	0.00	0.00	9.00	
43	27.000-	27.500	6.00	0.00	0.00	6.00	
44	27.500-	28.000	4.00	0.00	0.00	4.00	
45	28.000-	28.500	2.00	0.00	0.00	2.00	
46	28.500-	29.000	1.00	0.00	0.00	1.00	

SD 17

```
------------------------------ SD 18 ------------------------------
!                                                                  !
! Nemipterus marginatus. Research Trawl Survey. Manila bay.        !
!                                                                  !
!  a  n   Interval   Mean-L     S      N     Cal.N   S.I.   Index  !
! ---------------------------------------------------------------- !
!  1  9  6.50-11.00   8.674  0.861  9386    9387           (2-10) !
!  2  8 12.00-16.00  15.156  1.510  3635    3639    5.466 (13-20)!
!  3  3 17-00-18.50  18.727  1.298   908     927    2.543 (23-25)!
!  4  3 20.00-21.50  21.094  1.255   634     657    1.853 (29-31)!
!                                                                  !
!  We suggest that you quit this sample now                        !
!                                                                  !
------------------------------ SD 18 ------------------------------
```

```
------------------------------ SD 19 ------------------------------
!                                                                  !
! Nemipterus marginatus. Research Trawl Survey. Manila bay.        !
!                                                                  !
!  a  n   Interval   Mean-L     S      N     Cal.N   S.I.   Index  !
! ---------------------------------------------------------------- !
!  1  0  0.00-0.00    8.674  0.861     0    9387           (0-0)  !
!  2  0  0.00-0.00   15.156  1.510     0    3639    5.466  (0-0)  !
!  3  0  0.00-0.00   18.727  1.298     0     927    2.543  (0-0)  !
!  4  0  0.00-0.00   21.094  1.255     0     657    1.853  (0-0)  !
!                                                                  !
!  Adjusted for selection    L50% = 13    L75% = 15                !
!                                                                  !
!  Results from an earlier run                                     !
!                                                  !RETURN!        !
------------------------------ SD 19 ------------------------------
```

Having saved the results on disk the BHATTAC session is terminated by SD 20.

```
------------------------------ SD 20 ------------------------------
!                                                                  !
!              - - BHATTACHARYA ANALYSIS - -                       !
!                                                                  !
!    1 : Do more Bhattacharya analyses                             !
!                                                                  !
!    2 : Continue with modal progression GRAPH     (MODALGR)       !
!                                                                  !
!    3 : Continue with modal progression ANALYSIS  (MODALPR)       !
!                                                                  !
!    4 : Quit (return to main menu)                                !
!                                                                  !
!    Choose option (default = 2)                                   !
!                                                                  !
------------------------------ SD 20 ------------------------------
```

3.10.4. PRINTER OUTPUT.

As appeared from several screen displays in Section 3 you have the opportunity to get all the results you see on the sreen displayed on the printer as well. Normally one would not print them all. You may well run BHATTAC without producing any printer output, but postpone the printing of results to a subsequent run of the program MODALGR (cf. SD 20 in Section 3).

The printer outputs you may get from BHATTAC are (with references to the relevant menus) :

SD 3 : Table of adjustment for selection. If you ask for the printer you will get a table like SD 3 (but not in portions) with the run identification and the selection parameters (L50% and L75%)

SD 5 (Option 3) : Table of input to each component regression in the Bhattacharya analysis. Table like SD 6.

SD 7 (Option 'p') : Graph of Bhattacharya plot for each component.

SD 11 (Option 6) : Basic results (like SD 16)
(Option 8) : Table numbers (like SD 12)
(Option 10): Details of regression analysis (like SD 13)

3.10.5. CONNECTIONS TO OTHER PROGRAMS.

The files produced by BHATTAC are of the type :

"LENGTH FREQUENCY SAMPLE BHAT"

You may consider this type of file as a file of the type "LENGTH FREQUENCY SAMPLE" with the results of the Bhattacharya analysis attached to the end.

A file produced by BHATTAC can be read by the same programs as a file produced by LFINPUT or LFCONV (the suffix "BHAT" does not make the file inaccesible for such programs).

The continuation of BHATTAC are the programs :

MODALGR (Prints tables and graph of results of Bhattacharya analysis)

MODALPR (Modal progression analysis)

These programs require an input file of the type

"LENGTH FREQUENCY SAMPLE BHAT"

3.11. MODALGR.

3.11.1. PURPOSE.

MODALGR displays the results from a series of Bhattacharya analyses performed by the program BHATTAC.
MODALGR produces tables showing mean length, standard deviation and the number of individuals in each of the components.
MODALGR plots the modes of the components against the sampling time. This plot is the first step in the modal progression analysis (see manual for MODALPR).

3.11.2. INPUT / INPUT FILE.

The input file must be of the type :

" LENGTH FREQUENCY SAMPLE BHAT "

i.e. produced as an output file from the program BHATTAC.
The data used in this manual are the results of the analysis shown in the manual for BHATTAC. Only the first sample was analysed in that manual but the analyses have been completed and saved, and are now input for the example used to describe MODALGR.

3.11.3. SCREEN DIALOGUE.

After retrieval of the input data the usual summary follows as shown in SD 1. SD 1 also contains a column giving the number of components found in the BHATTAC-run.

```
-------------------------- SD 1 ------------------------------
!                                                            !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay.  !
!                                                            !
! The time series contains the samples :                     !
!                                                            !
!   s   year   month   day   time       no. of components    !
!  ---------------------------------------------------       !
!   1   1985   APR       4   1985.2575        4              !
!   2   1985   JUL       7   1985.5151        4              !
!   3   1985   OCT      15   1985.7890        4              !
!   4   1986   JAN      10   1986.0274        4              !
!                                                            !
!  Do you want to see the input data and/or                  !
!        change the input data (y/n), default = n  ! y !     !
!                                                            !
-------------------------- SD 1 ------------------------------
```

If you answer yes ('y') to the question in SD 1 you get SD 2, SD 3 and SD 4. SD 2 shows the mean length of the cohorts, SD 3 shows the stan-dard deviation of each cohort, and the number of specimens in each cohort is given in SD 4.

```
-------------------------- SD 2 -----------------------------
!                                                           !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay. !
!                                                           !
!   Sample date    Mean lengths of cohorts found            !
!  ------------------------------------------------------   !
!  1985  APR   4    8.674  15.156  18.727  21.094           !
!  1985  JUL   7   10.640  16.290  19.720  21.790           !
!  1985  OCT  15   12.460  17.390  20.380  22.200           !
!  1986  JAN  10   13.870  18.250  20.900  22.510           !
!  ------------------------------------------------------   !
!                                              !RETURN!     !
-------------------------- SD 2 -----------------------------


-------------------------- SD 3 -----------------------------
!                                                           !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay. !
!                                                           !
!   Sample date    Std. dev. of lengths found               !
!  ------------------------------------------------------   !
!  1985  APR   4    0.861   1.510   1.298   1.255           !
!  1985  JUL   7    1.064   1.629   1.972   2.179           !
!  1985  OCT  15    1.246   1.739   2.038   2.220           !
!  1986  JAN  10    1.387   1.825   2.090   2.251           !
!  ------------------------------------------------------   !
!                                              !RETURN!     !
-------------------------- SD 3 -----------------------------


-------------------------- SD 4 -----------------------------
!                                                           !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay. !
!                                                           !
!   Sample date    Cohort sizes found                       !
!  ------------------------------------------------------   !
!  1985  APR   4  9386.989  3639.275   926.568  657.161    !
!  1985  JUL   7  7284.000  2679.000   985.000  362.000    !
!  1985  OCT  15  5560.000  2045.000   752.000  276.000    !
!  1986  JAN  10  4374.000  1609.000   591.000  271.000    !
!  ------------------------------------------------------   !
!                                              !RETURN!     !
-------------------------- SD 4 -----------------------------
```

Notice that the figures in first line of SD 2, SD 3 and SD 4 are the results found in the Bhattacharya analysis as shown in SD 18 (page 19) in the manual for BHATTAC.

MODALGR offers an option for having the tables of SD 2, SD 3 and SD 4 displayed on the printer.

In SD 5 you can decide whether to change the results from BHATTAC shown in SD 2, SD 3 and SD 4. Answering 'y' in SD 5 produces a display of each sample (SD 6), and you may correct. As an example, the second sample is shown in SD 6.

```
------------------------ SD 5 ----------------------------
!                                                        !
! Do you want to change values (y/n), default = n ! y !  !
!                                                        !
------------------------ SD 5 ----------------------------
```

```
------------------------ SD 6 ----------------------------
!                                                        !
! Sample No. 2 1985 JUL   7                              !
!                                                        !
!                1        2        3        4           !
!    L       10.640   16.290   19.720   21.790          !
!    S        1.064    1.629    1.972    2.179          !
!    N     7284.000 2679.000  985.000  362.000          !
!                                                        !
! Do you want to change values (y/n), default = n ! y !  !
!                                                        !
------------------------ SD 6 ----------------------------
```

Adjustment of results from BHATTAC is illustrated in SD 7.

```
------------------------ SD 7 ----------------------------
!                                                        !
! Give cohort no.    ! 2 !                               !
! Give mean length, default = 16.29      ! 17.2 !        !
! Give std. dev.  , default = 1.629      !RETURN!        !
! Give number     , default = 2679       ! 700  !        !
!                                                        !
------------------------ SD 7 ----------------------------
```

After the correction the corrected data are shown (SD 8).

```
------------------------ SD 8 ----------------------------
!                                                        !
! Sample NO. 2 1986 JUL   7                              !
!                                                        !
!                1        2        3        4           !
!    L       10.640   17.200   19.720   21.790          !
!    S        1.064    1.629    1.972    2.179          !
!    N     7284.000  700.000  985.000  362.000          !
!                                                        !
! Do you want to change values (y/n), default = n !RETURN!!
!                                                        !
------------------------ SD 8 ----------------------------
```

The adjusted results are used in the present run only (adjusted results are not saved in a disk file).

After the adjustment (or directly from SD 1 or SD 5) SD 9 appears.

```
------------------------ SD 9 -------------------------------
!                                                           !
!           - - MODAL PROGRESSION GRAPH - -                 !
!                                                           !
!           1 : Produce screen size graph                   !
!                                                           !
!           2 : Produce large graph on printer              !
!                                                           !
!         Choose option, default = 1 !RETURN!               !
!                                                           !
------------------------ SD 9 -------------------------------
```

SD 9 offers the choice between a plot of screen size or a larger one (on the printer). SD 10 shows the screen size graph.

The graph (SD 10) shows for each sample the mean length of the cohorts.

On the graph the sampling date is plotted on the x-axis and the mean length on the y-axis.

In this example each sample contains 4 components and different symbols are used for each component within each sample.

The symbol used for the mean length of the component with the lowest mean length is '1'. The symbol used for the next component (with larger mean length) is '2', and higher numbers are used stepwise for the following components.

Thus, the figures on SD 10 are indices - not age groups !

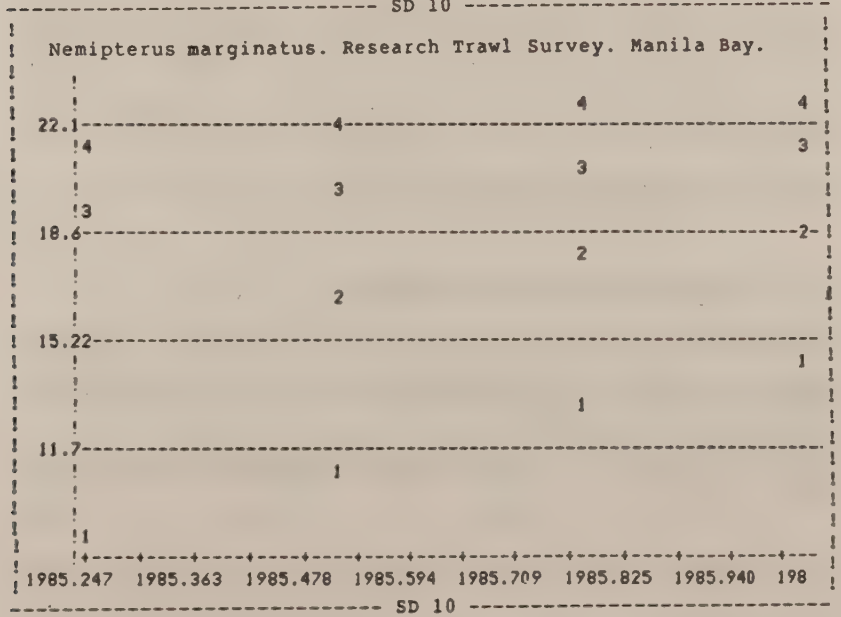


Figure 4.1 shows the large sized version of SD 10. The resolution in SD 10 may not always be sufficient for the use of the graph made when running the program MODALPR.

SD 11 offers alternative ways to proceed after the graphs.

```
------------------------ SD 11 -----------------------------
!                                                          !
!          - - MODAL PROGRESSION GRAPH - -                 !
!                                                          !
!  1 : Do one more graph with this data set                !
!                                                          !
!  2 : Do graphs with a new data set                       !
!                                                          !
!  3 : Continue with MODAL PROGRESSION ANALYSIS (MODALPR)  !
!                                                          !
!  4 : Quit ( return to main menu)                         !
!                                                          !
!  Choose option ( default = 3 )      !RETURN!             !
!                                                          !
------------------------ SD 11 -----------------------------
```

3.11.4. PRINTER OUTPUT.

The tables and the graph in SD 2, SD 3, SD 4 and SD 10 can be displayed on the printer.

Figure 3.11.4.1 shows the graph of SD 10 in large size. This graph was printed on two sheets of printer paper and subsequently fitted together.
The circles around the points were manually added by pencil.

The screen size graph uses 21 lines each of 75 characters. The large graph uses 100 lines each of 140 characters, so the resolution is much better than for the screen sized one.

When running the program MODALPR (modal progression analysis) it is often convenient to have the large sized graph.

3.11.5. CONNECTION TO OTHER PROGRAMMES.

MODALGR does not produce output files used by other programs.

MODALGR is linked with the program MODALPR, which performs the modal progression analysis.

MODALPR can be started by option 3 in SD 11. Adjustments made in the results in SD 7 will only be input to MODALPR if you access option 3 in SD 11.

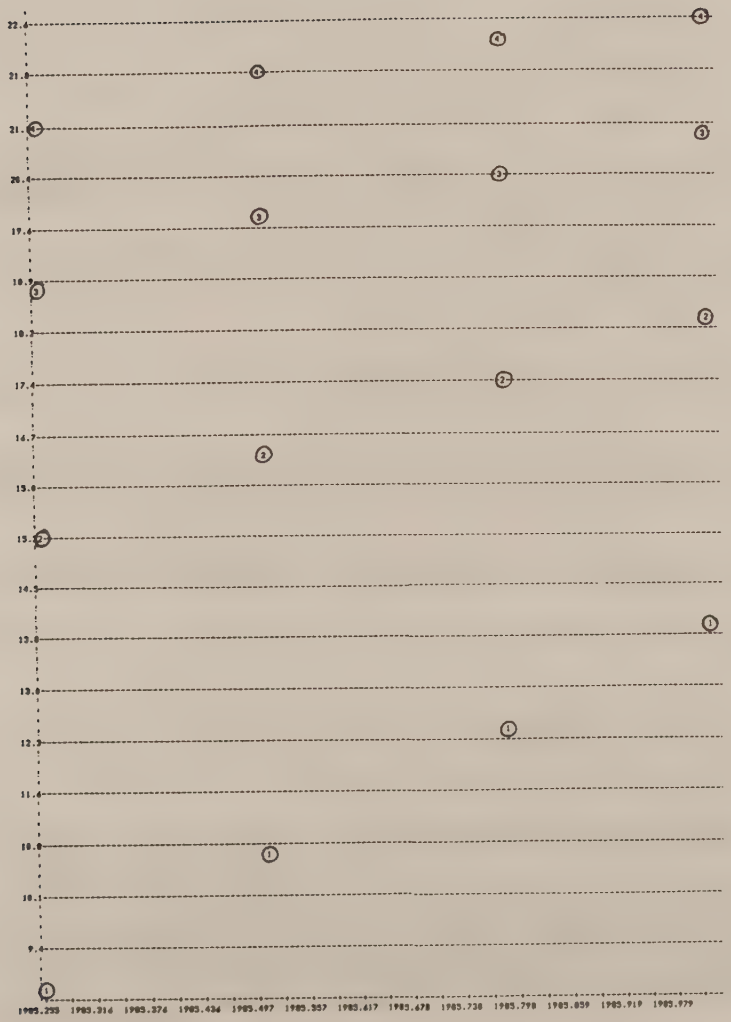


Figure 3.11.4.1. Large size graph (corresponds to SD 10).

3.12. MODALPR.

3.12.1. PURPOSE.

MODALPR performs modal progression analysis.

The structure of a length frequency analysis for estimation of growth parameters will typically be as follows:

A series of representative length frequency samples are separated into components using a Bhattacharya analysis (program BHATTAC). In this analysis the mean length of each component is estimated at a given time (the sampling date).
Next step in the analysis is to identify the cohorts and the progression of the modes by visual inspection. For this purpose a graph is needed.
A large size graph can be produced by the program MODALGR. Screen sized graphs are produced by MODALPR.

The input data to the program are the modes (mean lengths) of each component identified by BHATTAC.
In addition MODALPR requires input information on the cohort structure (from the visual inspection).

Using this information the MODALPR program carries out the regression analysis corresponding to the Gulland and Holt plot (Gulland and Holt, 1959) and thereby estimate the von Bertalanffy parameters L8 (L-infinity) and K (curvature parameter).

Using the estimated values for L8 and K the program then uses the von Bertalanffy plot to estimate the approximative birthday of each cohort.

The birthday analysis is further developed in the program GHBIRTH.

3.12.2. INPUT / INPUT FILE.

The input file must be of the type :

" LENGTH FREQUENCY SAMPLE BHAT "

i.e. the input file is an output file from the program BHATTAC.

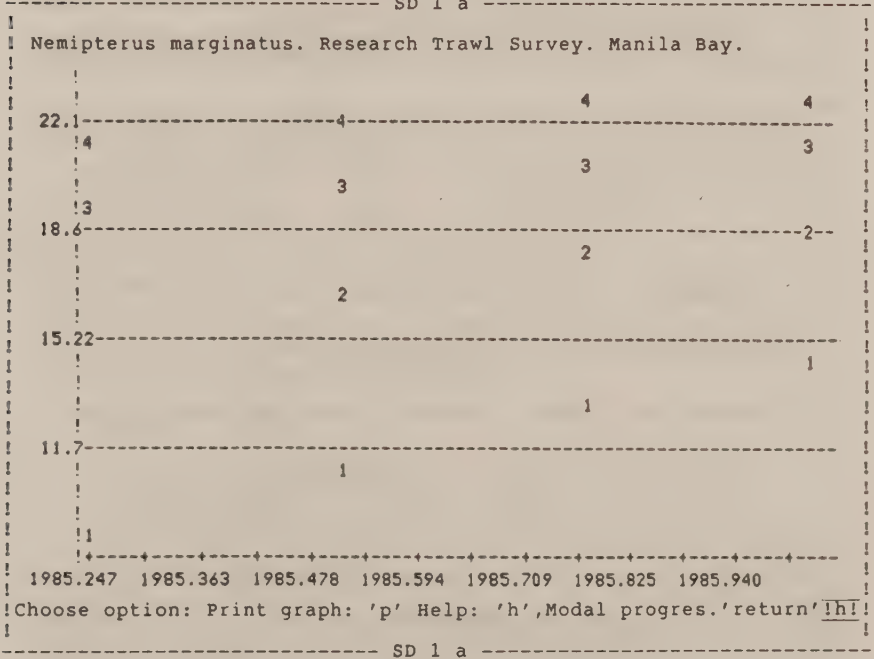
The data used to illustrate MODALPR is the result of the analysis shown in the manual for BHATTAC. Only the first sample was analysed in that manual but the analyses have been completed and saved, and are now the input example to MODALPR.
The same data were used as the example in the program MODALGR.

3.12.3. SCREEN DIALOGUE.

After retrieval of the input data file you get the same plot as when running the program MODALGR (SD 10 in screen size and the large version from the printer shown in Figure 3.11.4.1.

MODALPR only displays the screen size graph as shown in SD 1 a.

SD 1 a



SD 1 a

The graph shows for each sample the mean length of the components (cohorts). On the graph the sampling date is plotted on the x-axis and the mean length on the y-axis.
In this example each sample contains 4 components and different symbols are used for each component within each sample.
The symbol used for the mean length of the component with the lowest mean length is '1'. The symbol used for the next component (with larger mean length) is '2', and higher numbers are used stepwise for the following components. Thus, figures are indices - not age groups.

In this example it seems reasonable to assume that all the components labeled '1' in all four samples belong to the same cohort, and all the components labeled '2' seem to belong to another cohort recruited about one year earlier.

The example used here is based on hypothetical data. However, when analysing real data, the graph may not look so nice and it can be difficult to use specific rules for when components are linked together in cohorts.

The first step in the MODALPR analysis is to select those components which you think belong to the same cohort.
This identification of modal progression may be a rather subjective one if data are not of the same high quality as the hypothetical data.

The last line in SD 1 a offers three options. The first option 'p' displays the graph in SD 1 a on the prin-ter. The second option, 'h', gives an explanation of how to enter the data.

SD 2 shows the helping text.

```
---------------------------- SD 2 -------------------------------
!                                                               !
! To identify the cohorts you connect the peaks (components)    !
!                                                               !
! You do that by writing on the last line the number referring  !
! to components as shown in the example below :                 !
!                                                               !
!                                                               !
!  !-------------------------------------3--- This example deals !
!  !                    2                     with 3 samples    !
!  !                                                            !
!  !-------3-------------------------!2!-- Components :        !
!  !                    !1!                  Samp. 1 comp. 2   !
!  !                                         Samp. 2 comp. 1   !
!  !------!2!---------------------------1--- Samp. 3 comp. 2   !
!  !                                                            !
!  !       1                                 appear to form a  !
!  !+----+----+----+----+----+----+----+---- cohort            !
!                                                               !
!        ! 2           1              2 !                      !
!                                                               !
!                                                               !
! It is not necessary to place the figures exactly.             !
! If just the sequence is correct it's ok.                      !
!                                                               !
! On the next graph display the point selected will be replaced !
! by letters to indicate that these points have now been used.  !
!                                                               !
---------------------------- SD 2 -------------------------------
```

To continue with the modal progression analysis from SD 1 a you press 'RETURN' and SD 1 b is added to SD 1 a.

```
-------------------------- SD 1 b --------------------------
!                                                          !
! Connect components, Help 'h', Quit 'q', Continue RETURN  !
!                                                 !RETURN!!
!                                                          !
-------------------------- SD 1 b --------------------------
```

From the menu in the bottom line of SD 1 a (SD 1 b) you can get help , you can quit or you can continue the analysis.
At this stage of the analysis the obvious option is to continue.

When you press 'RETURN' the graph will remain on the screen but the bottom line is cleaned, ready for input.

Now you select from each sample the components you think belong to the same cohort.
In the present example we have already suggested the fact that all the components labeled '1' seem to belong to the same cohort.
The first number on the blank line should be be the number of the component from the first sample which you believe belongs to the cohort in question.
In this example the first number will be '1'.
From the next sample we will also select the component labeled '1' and the second number will be '1'.

As all the components to be linked to a cohort are labeled '1' the numbers

```
! 1 1 1 1 !
```

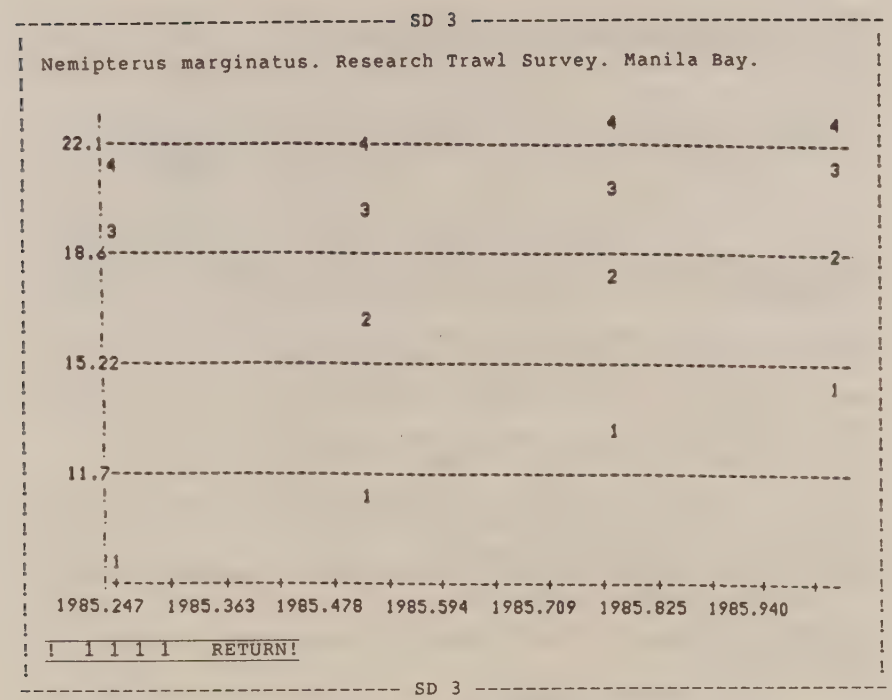
should be entered on the blank line as shown in SD 3.

The present example dealing with only four samples of hypothetical (well behaved) data appears easy to handle with the screen size graph.
With real data it might be an advantage to use the large size graph produced by the printer in MODALGR (see Figure 4.1 in the manual for MODALGR).

If you want to skip a sample and only want to join the components from the other samples you use zero '0' for the sample you want to skip.

An example: Suppose you want to include the first component in the first sample, the second component in the second sample, no components from the third sample, and first component in the fourth sample, then enter the numbers :

```
! 1 2 0 1 !
```

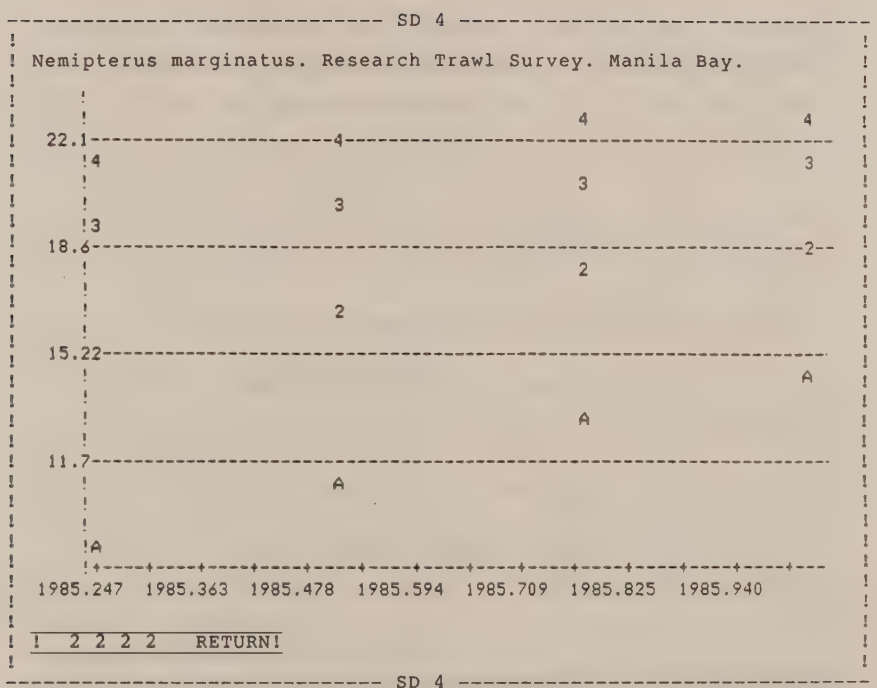


You can place the numbers at any position on the line you like, provided the sequence is correct and the figures are separated by at least one space.
As indicated in the 'help' text in SD 2 you need not select the smallest component in each sample. The decision is left to the user.

Pressing 'RETURN in SD 3 produces a graph in which the components already selected are indicated with letters as shown in SD 4.

To indicate the first cohort found the letter 'A' is used .
The bottom line on the screen will be similar to the bottom line in SD 1 and you are now ready to select components for the second cohort.
Entering 'RETURN' gives the same bottom line as in SD 1 a (SD 1 b), and a second 'RETURN' leaves the bottom line blank, ready for input of the numbers of the components which you think belong to the second cohort.

The selected components in this example are all the components labeled '2' as shown in the bottom line of SD 4.

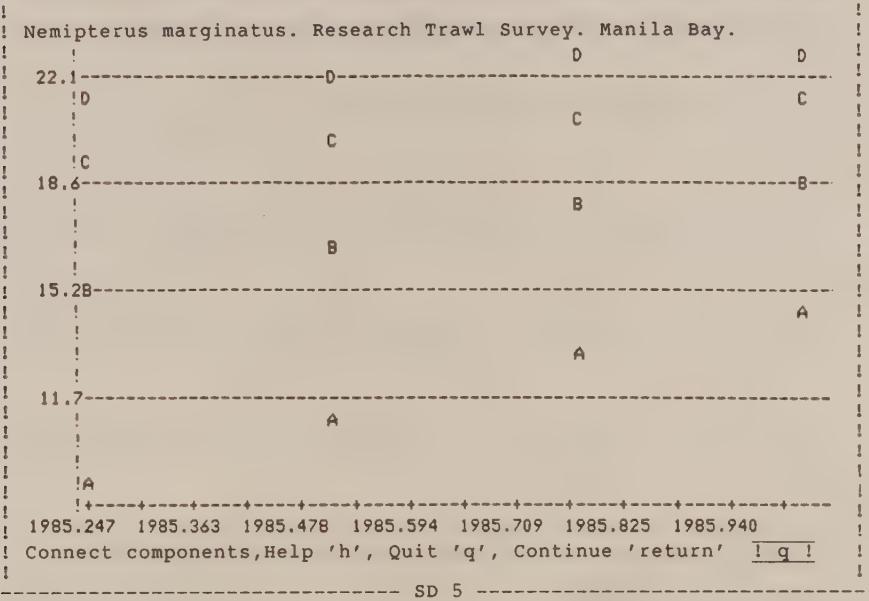


SD 5 shows the graph when all the components have been used (in this example four cohorts are identified).
In the example of SD 5 all points available were used, but it is not necessary for the analysis to use all of them. We might have finished the modal progression after SD 4 by using the 'q' (quit) option. In that case only the eight points from two first cohorts will be used in the estimation of growth parameters.

Often one should be cautious with using the mean estimates of lengths of old cohorts, because these are usually based on few observations and thus may not be well determined.
To assess the reliability of the mean length estimates one may use the output table from MODALGR (SD 4 in the manual for MODALGR)

But in SD 5 we have definitely finished this part of the analysis so the 'q' option is selected in the menu in the bottom line of SD 5.

SD 5


Nemipterus marginatus. Research Trawl Survey. Manila Bay.
22.1
18.6
15.28
11.7
1985.247 1985.363 1985.478 1985.594 1985.709 1985.825 1985.940
Connect components,Help 'h', Quit 'q', Continue 'return' ! q !

SD 5

The calculations are now carried out and the first results are shown in SD 6. SD 6 gives L8 (L-infinity) and K (curvature parameter) based on all data (all cohorts) combined, calculated by the Gulland and Holt plot :

$$Y(t1,t2) = a + b * X(t1,t2)$$

where

$$Y(t1,t2) = \frac{Lm(t2) - Lm(t1)}{t2 - t1} \quad \text{and} \quad X(t1,t2) = \frac{Lm(t1) + Lm(t2)}{2}$$

Lm(t1) and Lm(t2) are two consecutive mean lengths of components assigned to the same cohort. t1 and t2 are the corresponding sample times.

E.g. for the two first A's in SD 5 we get (compare SD 1 and SD 2 in the manual for MODALGR) :

$$Y(1985.25753,1985.51507) = \frac{10.640 - 8.675}{1985.51507 - 1985.25753} = 7.633$$

X(1985.25753,1985.51507) = (10.640 + 8.674)/2 = 9.657
(these figures are displayed in SD 13)

From the estimated slope and intercept K and L8 are derived :

$$K = -b \qquad L8 = -a/b$$

```
--------------------------- SD 6 -------------------------------
!                                                              !
! That was the Gulland & Holt analysis                         !
!                                                              !
! L8 = 25.7468962   K = .468599838                             !
!                                                              !
! Do you want to see details of the regression analysis        !
!                                    y/n, default = n  ! y !   !
!                                                              !
--------------------------- SD 6 -------------------------------
```

The details of the regression analysis are shown in SD 7.

Notice that K = - slope and that
L8 = - intercept/slope = 12.0649914/0.4685998 = 25.747

The input data for this regression are shown in the rightmost two columns of the table in SD 13.

The number of observations is 12 as there are four cohorts each of which contributes 3 values of Y = (Lm(t2)-Lm(t1))/(t2-t1) (compare SD 5).

```
--------------------------- SD 7 -------------------------------
!                                                              !
! Gulland & Holt plot                                          !
!                                                              !
! RESULTS OF REGRESSION ANALYSIS                               !
!                                                              !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay.    !
!                                                              !
! Number of observations  12                                   !
!                                                              !
!  Intercept  a            12.0649914                          !
!  std. dev. of intercept  .495761215                          !
!  Confidence interval of intercept 10.9594439 - 13.1705389    !
!                                                              !
!  Slope      b            -.468599838                         !
!  std. dev. of slope      .0275380472                         !
!  Confidence interval of slope      -.530009683 - -.407189992 !
!                                                              !
!  Mean value of x's       17.5384459                          !
!  Std. dev. of x's        4.24299462                          !
!  Mean value of y's       3.84647845                          !
!  Std. dev. of y's        2.02230777                          !
!                                                              !
!  Correlation coeff.  r   -.983167159                         !
!                      r*r  .966617663                         !
!  Confidence interval of r          -.995414854 - -.939200644 !
!                                                              !
--------------------------- SD 7 -------------------------------
```

SD 8 shows the results of the birthday analysis of cohort A.

By the "approximative birthday" we understnd :

absolute birthday (of cohort) - t-zero

I.e. the approximate birthday estimated by the von Bertalanffy plot :

$$Y = a + b * X$$

where $Y = -\log(1 - Lm(t)/L8)$ and $X = t$ (sample time)

$a = -K * \text{birthday}$ $b = K$

Approximate birthday $= -a/b$

(t,Lm(t)) takes all the values corresponding to points assigned to cohort A (in this case 4 values).

```
------------------------ SD 8 --------------------------------
!                                                            !
! That was the von Bertalanffy analysis for cohort A         !
!                                                            !
!   Birth day  1984.38459    Number of obs. 4                !
!                                                            !
! Do you want to see details of the regression analysis      !
!                                    y/n, default = n  ! y !  !
!                                                            !
------------------------ SD 8 --------------------------------
```

This is the same analysis as used in the program GHBIRTH. The only difference is that GHBIRTH gives an estimate of the average birthday based on data combined for several cohorts.

SD 9 shows the details of the regression analysis.

Notice that the mean value of the X's is :

1985.6473 = (1985.25753 + 1985.51507 + 1985.78904 + 1986.0274)/4

The four figures in the bracket are the four sample times (compare SD 1 in the manual for MODALGR).

Notice further that

- intercept/slope = 934.788634/0.4710723 = 1984.3846 = birthday.

The slope (= 0.471) is an alternative estimate of K.

```
---------------------------- SD 9 -------------------------------
!                                                               !
! Von Bertalanffy plot for cohort A   Birthday  1984.34459      !
!                                                               !
!  RESULTS OF REGRESSION ANALYSIS                               !
!                                                               !
!  Nemipterus marginatus. Research Trawl Survey. Manila Bay.    !
!                                                               !
!  Number of observations  4                                    !
!                                                               !
!                                                               !
!  Intercept  a            -934.788634                          !
!  std. dev. of intercept  1.84320998                           !
!  Confidence interval of intercept -942.714437 - -926.862831   !
!                                                               !
!  Slope      b            .471072311                           !
!  std. dev. of slope      9.28266564E-04                       !
!  Confidence interval of slope     .467080765 - .475063857     !
!                                                               !
!  Mean value of x's       1985.64726                           !
!  Std. dev. of x's        .333652153                           !
!  Mean value of y's       .594810513                           !
!  Std. dev. of y's        .157174901                           !
!                                                               !
!  Correlation coeff.  r   .999996117                           !
!                      r*r .999992234                           !
!  Confidence interval of r         .999804295 - .999999923     !
!                                                               !
---------------------------- SD 9 -------------------------------
```

The von Bertalanffy results for the remaining cohorts named B, C and D in this example follows after SD 9. These are shown in SD 10, SD 11 and SD 12.

```
------------------------ SD 10 ------------------------------
!                                                           !
! That was the von Bertalanffy analysis for cohort B        !
!                                                           !
!   Birthday   1984.28102    Number of obs. 4               !
!                                                           !
! Do you want to see details of the regression analysis     !
!                                  y/n, default = n !RETURN! !
------------------------ SD 10 ------------------------------

------------------------ SD 11 ------------------------------
!                                                           !
! That was the von Bertalanffy analysis for cohort C        !
!                                                           !
!   Birthday   1984.49551    Number of obs. 4               !
!                                                           !
! Do you want to see details of the regression analysis     !
!                                  y/n, default = n !RETURN! !
------------------------ SD 11 ------------------------------
```

```
------------------------ SD 12 -------------------------------
!                                                            !
! That was the von Bertalanffy analysis for cohort D         !
!                                                            !
!   Birthday   1984.53202    Number of obs. 4                !
!                                                            !
! Do you want to see details of the regression analysis      !
!                                    y/n, default = n !RETURN! !
------------------------ SD 12 -------------------------------
```

SD 13 shows the results af the Gulland & Holt analysis and the von Bertalanffy analyses together with the input data for the Gulland and Holt plot.
"mean-L" is the independent variable (X) and dL/dt is the dependent variable (Y).

```
------------------------------ SD 13 -------------------------------
!                                                                  !
! Gulland & Holt plot.   Von Bertalanffy plot                      !
!                                                                  !
! L8                    25.7468962                                 !
! Confidence interval 23.387639 - 28.1061533  (Conditioned on K)   !
! K                     .468599838                                 !
! Confidence interval .407189992 - .530009683                      !
!                                                                  !
!      t1   Dates    t2          dt      L(t1)    L(t2)   mean-L   dL/dt  !
! ---------------------------------------------------------------------- !
! APR  4 1985  JUL  7  1985    0.257     8.674   10.640    9.657   7.633  !
! JUL  7 1985  OCT 15  1985    0.274    10.640   12.460   11.550   6.643  !
! OCT 15 1985  JAN 10  1986    0.238    12.460   13.870   13.165   5.915  !
! Birth day : 1984.384 - t0 + 'deviation from v. Bert. model'             !
! ---------------------------------------------------------------------- !
! APR  4 1985  JUL  7  1985    0.257    15.156   16.290   15.723   4.399  !
! JUL  7 1985  OCT 15  1985    0.274    16.290   17.390   16.840   4.015  !
! OCT 15 1985  JAN 10  1986    0.238    17.390   18.250   17.820   3.608  !
! Birth day : 1983.281 - t0 + 'deviation from v. Bert. model'             !
! ---------------------------------------------------------------------- !
! APR  4 1985  JUL  7  1985    0.257    18.727   19.720   19.223   3.853  !
! JUL  7 1985  OCT 15  1985    0.274    19.720   20.380   20.050   2.409  !
! OCT 15 1985  JAN 10  1986    0.238    20.380   20.900   20.640   2.181  !
! Birth day : 1982.495 - t0 + 'deviation from v. Bert. model'             !
! ---------------------------------------------------------------------- !
!                                                                        !
! APR  4 1985  JUL  7  1985    0.257    21.094   21.790   21.442   2.702  !
! JUL  7 1985  OCT 15  1985    0.274    21.790   22.200   21.995   1.496  !
! OCT 15 1985  JAN 10  1986    0.238    22.200   22.510   22.355   1.300  !
! Birth day : 1981.532 - t0 + 'deviation from v. Bert. model'             !
! ---------------------------------------------------------------------- !
!                                                                        !
! Do you want the table printed (y/n) default = y !RETURN!               !
!                                                                        !
------------------------------ SD 13 -------------------------------
```

SD 14 asks if you want to save the results of the analysis. This must be done if you want to use the results for a "birthday analysis" or if you want to see the Gulland and Holt plot of the above analysis by running the program GHBIRTH.

```
---------------------------- SD 14 -----------------------------
! Do you want to save the results on diskette (y/n), default=y !
!                                                    !RETURN!  !
---------------------------- SD 14 -----------------------------
```

The modal progression analysis has now been completed and the terminal screen display in MODALPR is SD 14. This menu offers the option of a new analysis on the same data, modal progression on a new data set, quit, or perhaps the most relevant option, to continue with the program GHBIRTH.
GHBIRTH produces the plot of the Gulland & Holt analysis carried out in MODALPR.

```
---------------------------- SD 14 -----------------------------
!                                                              !
!    - -  MODAL PROGRESSION ANALYSIS - -                       !
!                                                              !
!  1 : Do one more analysis on this data set                   !
!  2 : Do one more analysis on a new data set                  !
!  3 : Print Gulland and Holt plot or/and do birthday analy-   !
!      sis (Results of MODALPR must be saved before option 3)  !
!  4 : Quit (return to main menu)                              !
!                                                              !
!    Choose option ! 3 !                                       !
!                                                              !
---------------------------- SD 14 -----------------------------
```

3.12.4. PRINTED OUTPUT.

Using the relevant options in the menus all tables and graphs shown above can be displayed on the printer.

To get a plot of the Gulland and Holt analysis the program GHBIRTH must be run.

3.12.5. CONNECTION TO OTHER PROGRAMMES.

MODALPR produces a disk file of the type

" Results of modal progression analysis "

which can be used as input to the program GHBIRTH (Gulland and Holt plot / birthday analysis).

3.13. GHBIRTH.

3.13.1. PURPOSE.

GHBIRTH has two purposes, both of which are continuations of the analysis performed by the program MODALPR.
One purpose is to produce the graph of the Gulland and Holt plot, which is used in the program MODALPR to estimate the von Bertalanffy growth parameters.
The other purpose of GHBIRTH is to perform the birthday analysis :

The parameter t-zero (to) in the von Bertalanffy equation written in the traditional way

```
L(t)= L8*(1 - exp(-K*(t-to)) )
```

represents the (usually negative) age of the fish where it has zero length. It is not possible to estimate t-zero from length frequency data only. (t-zero can be estimated only if absolute ages are known).

By the "approximate birthday" we understand :

absolute birthday (of the cohort) - t-zero

The approximate birthday can be estimated by the von Bertalanffy plot :

$$Y = a + b * X$$

where

Y	=	$-\log(1 - Lm(t)/L8)$
X	=	t + A
t	=	sampling time
Lm(t)	=	mean length of cohort at time t
A	=	age group of cohort at time t

approximate birthday = - a/b

This is in principle the same analysis as that performed by MODALPR. The only difference is that MODALPR uses data for one cohort only at a time whereas GHBIRTH combines several cohorts for estimation of the average birthday.

3.13.2. INPUT/ INPUT FILE.

The input file must be of the type:

" results of modal progression analysis "

i.e. created by the program MODALPR.
The example used in this manual is a continuation of the example used in the manual for MODALPR. The data were analysed by MODALPR and saved and the file now serve as input for GHBIRTH.

3.13.3. SCREEN DIALOGUE.

The first screen display shows the main menu of GHBIRTH. Option 1 starts the birthday analysis which will be discussed below.

```
------------------------  SD 1  -------------------------------
!                                                             !
!     - - GULLAND & HOLT PLOT / BIRTHDAY - -                  !
!                                                             !
!   1 : Do birthday analysis (v. Bert. plot)                  !
!   2 : Do graph of Gulland and Holt plot                     !
!   3 : Do one more analysis on a NEW data set                !
!   4 : Quit (return to main menu)                            !
!                                                             !
!           Choose option ! 1 !                               !
!                                                             !
------------------------  SD 1  -------------------------------
```

BIRTHDAY ANALYSIS.

SD 2 shows a summary of the cohorts which were identified in the modal progression analysis (compare SD 13 in the manual for MODALPR).
In SD 2 you are requested to enter the number on those cohorts which you think belong to the same spawning season. If it is believed that there is only one major spawning season per year, each of your cohorts must belong to the same season.

If you consider it likely that there are two spawning seasons per year, then some of the cohorts may be classified as spring cohorts and others as autumn cohorts. In this case the birthday analysis is separated into an analysis for the spring cohorts and one for the autumn cohorts.

In the present example only one spawning period per year is assumed, and all cohorts therefore belong to the same spawning season.
The columns in SD 2 refer to results obtained in the run with the program MODALPR (which must be done before the input file to GHBIRTH can be created).
The estimated birthday was found in MODALPR for each cohort separately and these values are shown in the third column in SD 2.
The rightmost column shows the length range of component mean lengths which were used in MODALPR to estimate the birthday.
The second column (No. of obs.) shows the number of component mean length used in the analysis.

The purpose of SD 2 is to make it easier to select the cohorts to be used in the analysis, i.e. to select cohorts originating from the same spawning season (e.g. autumn cohorts and spring cohorts).

The length range is given because you may want to exclude cohorts based only on large (old) specimens. Estimation of birthday becomes safer the closer the observations are to the birthday.

```
--------------------------- SD 2 -------------------------------
!                                                              !
!     - - GULLAND & HOLT PLOT / BIRTHDAY - -                   !
!                                                              !
! Cohort  No. of obs.  Estim.Birthday       Length range       !
!--------------------------------------------------------------!
!   1         4           1984.384          8.6740 -  13.8700  !
!   2         4           1983.281         15.1568 -  18.2500  !
!   3         4           1982.495.        18.7277 -  20.9000  !
!   4         4           1981.532         21.0941 -  22.5100  !
!                                                              !
!  Give indices of cohorts from the same season ( help 'h')    !
!                                                              !
!  ! 1 2 3 !                                                   !
!                                                              !
--------------------------- SD 2 -------------------------------
```

SD 3 shows the text which is offered as help in SD 2.

```
--------------------------- SD 3 -------------------------------
!                                                              !
! You enter the indices of all cohorts on one line separated  !
! by spaces. You can enter in any order.                       !
! If you e.g. wish to select cohorts 1,3 and 4 then you write  !
!                                                              !
!   1  3  4                                                    !
!                                                              !
! To run this program you should use the output from the       !
! MODAL PROGRESSION ANALYSIS (Tables and/or graphs)            !
! In this way you should be in a position to guess on age      !
! differences between cohorts.                                 !
!                                                              !
! You have to decide whether you think there is one cohort     !
! per year or two cohorts per year                             !
! If you think there is only one cohort per year you should    !
! (ideally) use all components in the estimation of birthday.  !
! If you think there are two cohorts per year you should       !
! (ideally) split the cohorts into two groups, each of which   !
! accounts for a recruitment season.                           !
--------------------------- SD 3 -------------------------------
```

In the example of SD 2 we chose to use the three first cohorts in the analysis.
In SD 4 age groups are assigned to cohorts. SD 5 shows the explanatory text produced by 'h'.
In the present example it is assumed that there is one year between the cohorts (see SD 4).
The sequence of age groups given as input does not need to be 0,1,2,3,.... If you, for example, think that there are two years between the first two cohorts and only one year between the second and the third cohort you should enter 0,2,3. That might be the case if the (missing) 1 group came from a poor recuitment so that it was detectable in the Bhattacharya analysis.
If you enter e.g. 1.324 for the age group (which is illigal according to SD 5) the program does not accept the input and repeats the prompt.

```
--------------------------- SD 4 -------------------------------
!                                                               !
!    Assign age groups to cohorts. ( Help 'h')                  !
!                                                               !
! Cohort No. of obs.  Estim. Birthday  Length range  age group !
!-------------------------------------------------------------!
!   1       4          1984.3646       8.6740 - 13.8700  ! 0  !!
!   2       4          1983.2810      15.1568 - 18.2500  ! 1  !!
!   3       4          1982.4955      18.7277 - 20.9000  ! 2  !!
!                                                               !
!   Is input OK ? (y/n) default = y  !RETURN!                   !
!                                                               !
--------------------------- SD 4 -------------------------------
```

```
--------------------------- SD 5 -------------------------------
!                                                               !
! Assign age groups.                                            !
!                                                               !
! If you think there is one cohort per year the age groups      !
! should be integer, e.g., 0,1,2,...                            !
!                                                               !
! If you think there are two cohorts per year the age groups    !
! should be  0,  0.5,  1.0,  1.5,  2.0, ....                    !
! No other age group specifications are allowed                 !
!                                                               !
! It does not matter what value you assign to the first age     !
! group as it is only the differences which count, e.g.         !
! 0,1,2,3,.... gives the same results as 117,118,119,120,...    !
!                                                               !
--------------------------- SD 5 -------------------------------
```

After SD 4 the results are shown in SD 6, SD 7 and SD 8.

```
--------------------------- SD 6 -------------------------
!                                                        !
!   von Bertalanffy plot                                 !
!                                                        !
!    Birth day  0.32526      Number of obs. 12           !
!       29 APR                                           !
!       L8 = 25.74                                       !
!                                                        !
! Do you want to see details of regression analysis, y/n !
!                                      default= n ! y !  !
--------------------------- SD 6 -------------------------
```

The birthday is given as a fraction of the year.

0.32526 corresponds to the day number which is the integer part of the real number 365 * 0.32526 i.e. day number 119 which corresponds to 29. April.

SD 7

RESULTS OF THE REGRESSION ANALYSIS

Nemipterus marginatus. Research Trawl Survey. Manila Bay

Number of observations 12

Intercept a	.305550774
std. dev. of intercept	7.69275804E-03
Confidence interval of intercept	.288395924 - .322705625
Slope b	.452845054
std. dev. of slope	4.13348747E-03
Confidence interval of slope	.443627377 - .462062731
Mean value of x's	1.64726007
Std. dev. of x's	.904630203
Mean value of y's	1.05150435
Std. dev. of y's	.409827935
Correlation coeff. r	.999583674
r*r	.999167523
Confidence interval of r	.998463021 - .999887275

SD 7

SD 8

Date	age gr.	L	- Log(1-L/L8)	t+a+T2 *)
1985 APR 4	0	8.6740	0.4108	0.2575
1985 JUL 7	0	10.6400	0.5331	0.5150
1985 OCT 15	0	12.4600	0.6615	0.7890
1986 JAN 10	0	13.8700	0.7737	1.0274
1985 APR 4	1	15.1568	0.8884	1.2575
1985 JUL 7	1	16.2900	1.0015	1.5150
1985 OCT 15	1	17.3900	1.1252	1.7890
1986 JAN 10	1	18.2500	1.2338	2.0274
1985 APR 4	2	18.7277	1.2996	2.2575
1985 JUL 7	2	19.7200	1.4520	2.5150
1985 OCT 15	2	20.3800	1.5680	2.7890
1986 JAN 10	2	20.9000	1.6699	3.0274

*) T1 = first year sampled = 1985

SD 8

SD 8 shows the input data for von Bertalanffy regression. Notice that 1985 (first sample year) has been subtracted from all sample times. As we are here only concerned with the decimal part of the results the three first digit in the time are unimportant.

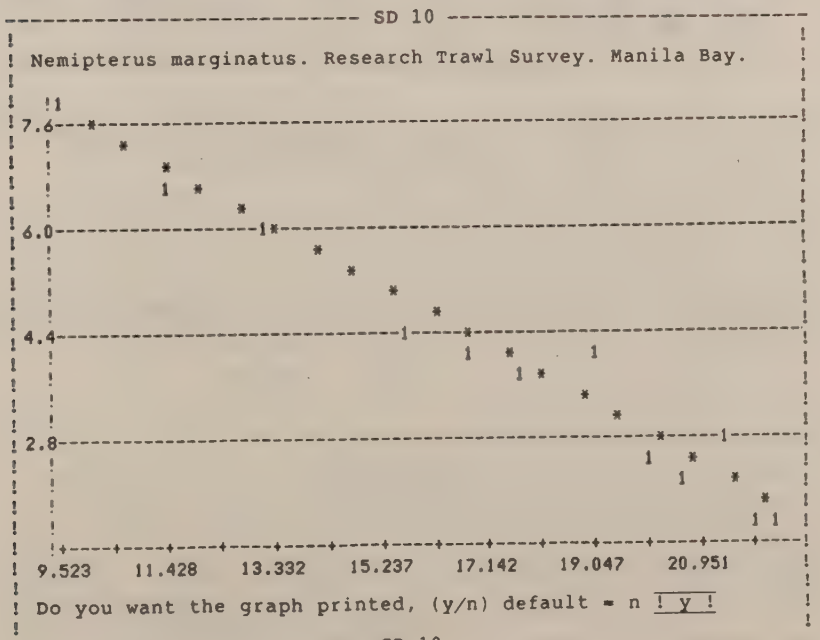
GULLAND AND HOLT PLOT.

Selecting option 2 in SD 1 produces the graph for the Gulland and Holt plot from the run of program MODALPR and in addition GHBIRTH also produces some output tables slightly different from those produced by MODALPR.

In SD 9 two different graph sizes are offered.

```
------------------------- SD 9 ----------------------------
!                                                          !
!     - - GULLAND & HOLT PLOT / BIRTHDAY - -               !
!                                                          !
!     1 : Produce screen size graph                        !
!                                                          !
!     2 : Produce large graph on printer                   !
!                                                          !
!     Choose option, default = 1 !RETURN!                  !
!                                                          !
------------------------- SD 9 ----------------------------
```

SD 10 shows the screen size graph of the Gulland & Holt plot for the analysis used as an example in the manual for MODALPR.



SD 11

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

Gulland & Holt plot.

L8	25.7468962
Confidence interval	23.387639 - 28.1061533 (Conditioned on K)
K	.468599838
Confidence interval	.407189992 - .530009683

t1	Dates	t2	dt	L(t1)	L(t2)	mean-L	dL/dt
APR 4 1985	JUL 7 1985		0.257	8.674	10.640	9.657	7.633
JUL 7 1985	OCT 15 1985		0.274	10.640	12.460	11.550	6.643
OCT 15 1985	JAN 10 1986		0.238	12.460	13.870	13.165	5.915
APR 4 1985	JUL 7 1985		0.257	15.156	16.290	15.723	4.399
JUL 7 1985	OCT 15 1985		0.274	16.290	17.390	16.840	4.015
OCT 15 1985	JAN 10 1986		0.238	17.390	18.250	17.820	3.608
APR 4 1985	JUL 7 1985		0.257	18.727	19.720	19.223	3.853
JUL 7 1985	OCT 15 1985		0.274	19.720	20.380	20.050	2.409
OCT 15 1985	JAN 10 1986		0.238	20.380	20.900	20.640	2.181
APR 4 1985	JUL 7 1985		0.257	21.094	21.790	21.442	2.702
JUL 7 1985	OCT 15 1985		0.274	21.790	22.200	21.995	1.496
OCT 15 1985	JAN 10 1986		0.238	22.200	22.510	22.355	1.300

SD 11

SD 11 gives a table which is the same as the table shown in SD 12 in the manual for MODALPR, except for that the estimates of birthdays for individual cohorts have been deleted.

3.13.4. PRINTER OUTPUT.

As appeared from the screen displays all tables displayed on the screen can be displayed on the printer as well. In addition SD 9 option 2 offers a large size (70 lines each of 140 characters) of the Gulland and Holt graph.

3.13.5. CONNECTION TO OTHER PROGRAMMES.

GHBIRTH does not produce disk files used by other programs.

3.14. CCURVE.

3.14.1. PURPOSE.

The purpose of program CCURVE is to perform the length converted catch curve analysis for estimation of total mortality and to estimate selection ogives (lengths at 50% and 75% retension) :

The length converted catch curve analysis is the regression analysis :

$$\log(C(j)/dt) = A - Z*t(j)$$

where

C(j) = number caught in lenght group no. j
dt = the time it takes to grow through length group no. j.
t(j) = mean age of a fish in length group no. j.
Z = total mortality coefficient

The length groups used in this regression are the large ones, i.e. those under full explotation.

The selection ogive is approximated by the logistic curve :

$$\text{Fraction retained} = 1/(1 + \exp(s1 - s2*\text{Length}))$$

where s1 = log(3)/(L75%-L50%)
s2 = L50%*s2
L50% = 50 % retension length.
L75% = 75 % retension length.

The logistic model is turned into a linear regression analysis. The length groups used in this regression are the small ones, i.e. those not under full explotation.

The length converted catch curve analysis originally introduced by van Sickle, 1977 is discussed in Pauly, 1983, 1984a and 1984b and Sparre, 1985.

3.14.2. INPUT / INPUT FILE.

The input file must be of the type :

"weighted sum of length frequencies"

i.e. it must have been produced by option 1 of program LFMANI.

An example is shown in Table 3.14.2.1. Actually this example is the sum of the four samples used as an example in the manuals for BHATTAC and MODALPR.
The length groups have been combined from 0.5 cm groups to 1 cm groups (using option 2 in LFMANI)

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

SUM OF FREQUENCIES

s	year	month	day	weighting factor
1	1985	APR	4	1
2	1985	JUL	7	1
3	1985	OCT	15	1
4	1986	JAN	10	1

Interval	frequency
6.00 - 7.00	7
7.00 - 8.00	91
8.00 - 9.00	355
9.00 - 10.00	551
10.00 - 11.00	758
11.00 - 12.00	1113
12.00 - 13.00	1473
13.00 - 14.00	1856
14.00 - 15.00	2077
15.00 - 16.00	2106
16.00 - 17.00	2010
17.00 - 18.00	1852
18.00 - 19.00	1653
19.00 - 20.00	1417
20.00 - 21.00	1158
21.00 - 22.00	899
22.00 - 23.00	660
23.00 - 24.00	452
24.00 - 25.00	284
25.00 - 26.00	164
26.00 - 27.00	84
27.00 - 28.00	40
28.00 - 29.00	12
Total	21072

Table 3.14.2.1. Example of input data to CCURVE.
(output from LFMANI).

3.14.3. SCREEN DIALOGUE.

After retrieval of the file SD 1 appears and you are asked to enter the von Bertalanffy parameters K (the curvature parameter) and L8 (L-infinity).

As you will see (SD 5 and SD 11), the program offers you the option to redo the analysis with new parameters. If you are rerunning the analysis, the default values will not be zero but will be the values you selected in the foregoing run.

```
------------------------- SD 1 -------------------------------
!                                                           !
!       - - LENGTH CONVERTED CATCH CURVE ANALYSIS - -       !
!                                                           !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay. !
!                                                           !
!  Length range          6 - 29                             !
!                                                           !
!  Give L-infinity , default = 0  ! 30 !                    !
!                                                           !
!  Give K ,           default = 0  ! 0.4 !                  !
!                                                           !
! Do you want the regression weighted by square root of numbers!
!                                  (y/n), default = y !RETURN!  !
!                                                           !
! Is input ok ? (y/n) default = y !RETURN!                  !
!                                                           !
------------------------- SD 1 -------------------------------
```

The regression analysis of the catch curve analysis is :

$$Y(j) = A + B * X(j)$$

where $X(j)$ = (relative) age at length $L(j)$

$$= - (1/K) * \log (1 - (L(j)+dL/2)/L8)$$

and $Y(j) = \log (C(j)/dt(j))$

where

$L(j)$ = Lower limit of length group no j.

dL = Length interval size

K = Von Bertalanffy parameter (curvature parameter)

$L8$ = Von Bertalanffy parameter (Asymptotic length)

$dt(j)$ = The time it takes to grow from length $L(j)$ to $L(j+1)$
$= (1/K) \ln((L8-L(j+1))/(L8-L(j)))$

$C(j)$ = Number caught in length group no. j , i.e. fish of lengths between $L(j)$ and $L(j+1) = L(j)+dL$

The weighted regression is the regression of Y on X weighted by V C(j) (the weighting is optional).

Let A and B be the intercept and slope respectively. Then the total mortality coefficient is estimated by :

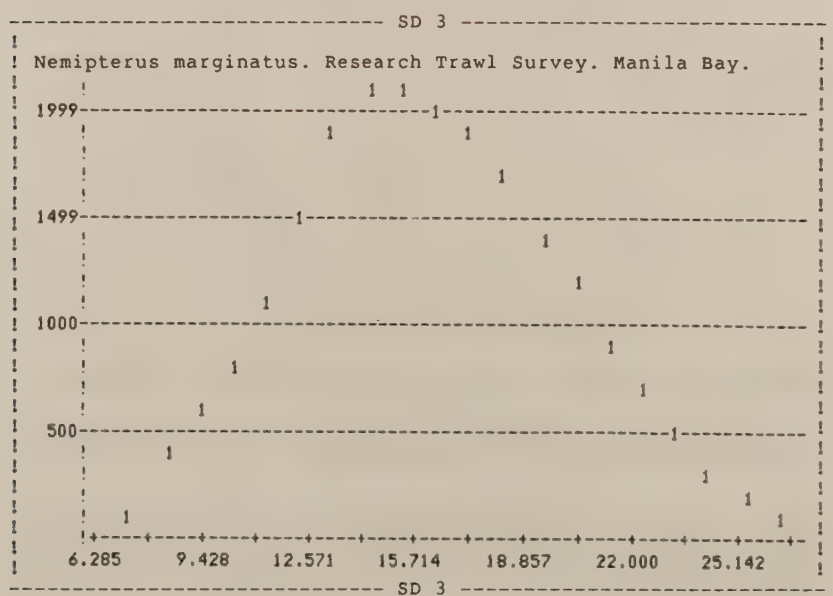
$$Z = - B$$

The intercept, A, is not used in the catch curve analysis, but in the subsequent analysis both A and B are used for estimation of the selection ogive.

```
---------------------------- SD 2 -----------------------------
!                                                             !
! SELECT RANGE OF LENGTHS TO BE USED IN ANALYSIS              !
! Look at the data below - do not include zero-observations   !
!                                                             !
! If you want plot on screen enter 's'                        !
! If you want plot on printer enter 'p'                       !
!                                                             !
!                          (option : 'e' to end looking over) !
! Index   Interval        frequency                           !
! ------------------------------------                        !
!   1    6.00 -  7.00         7  I !RETURN!                  !
!   2    7.00 -  8.00        91  I !RETURN!                  !
!   3    8.00 -  9.00       335  I !RETURN!                  !
!   4    9.00 - 10.00       551  I !RETURN!                  !
!   5   10.00 - 11.00       758  I !  s   !                  !
!                                                             !
---------------------------- SD 2 -----------------------------
```

In SD 2 you are asked to enter the range for the regression, i.e. the first index and the last index for the points used in the regression. We call the indices defining the length range in the regression j1 and j2. Thus the regression is

$$Y(j) = a + b * X(j), \quad j = j1, j1+1, j1+2, \ldots, j2$$



To facilitate the choice the frequencies are displayed on the sreen (SD 2 and SD 4).
You scroll through the list by repeatedly using the RETURN-key.
You may supress the listing by entering 'e'.
Another option, 's', is to get the frequencies depicted as a graph, as shown in SD 3.
The options 'e', 's' or 'p' can be entered at any stage during the scrolling process.
In SD 4 the entire length frequency has been listed. In the last two lines you enter the first and the last index for the range used in the regression.

SD 4

SELECT RANGE OF LENGTHS TO BE USED IN ANALYSIS
Look at the data below - do not include zero-observations

If you want plot on screen enter 's'
If you want plot on printer enter 'p'

(option : 'e' to end looking over)

Index	Interval	frequency	
1	6.00 - 7.00	7	I
2	7.00 - 8.00	91	I
3	8.00 - 9.00	355	I
4	9.00 - 10.00	551	I
5	10.00 - 11.00	758	I
6	11.00 - 12.00	1113	I
7	12.00 - 13.00	1473	I
8	13.00 - 14.00	1856	I
9	14.00 - 15.00	2077	I
10	15.00 - 16.00	2106	I
11	16.00 - 17.00	2010	I
12	17.00 - 18.00	1852	I
13	18.00 - 19.00	1653	I
14	19.00 - 20.00	1417	I
15	20.00 - 21.00	1158	I
16	21.00 - 22.00	899	I
17	22.00 - 23.00	660	I
18	23.00 - 24.00	452	I
19	24.00 - 25.00	284	I
20	25.00 - 26.00	164	I
21	26.00 - 27.00	84	I
22	27.00 - 28.00	40	I
23	28.00 - 29.00	12	I

Give index of first length group in reg. analysis ! 11 !
Give index of last length group in reg. analysis ! 21 !

Is input ok ? (y/n) default = y !RETURN!

SD 4

After SD 4 the calculations start. If one of the observations in the selected range was a zero observation you will get a message and the calculations will be aborted.

SD 5 offers you four different displays either on screen or printer. They are shown in SD 6, SD 7, SD 8 and SD 9.

The graph of the length converted catch curve shown in SD 7 is scaled so that the rescaled values, Yr, become :

$$Yr(j) = INT(20*(Y(j)-Ymin)/(Ymax-Ymin)+.4999)$$

where

INT = integer part of a real figure

Ymax and Ymin are the maximum and the minimum Y-values respectively. The figure "20" reflects the number of available lines. The Xs are rescaled in a similar way. The figures on the axes are rounded figures.

"1" on the graph stands for an observation, and "*" stands for a calculated value, i.e. a point on the regression line. If an observed and a calculated point coincide the symbol "A" is used (cf. SD 1 in Section 2.7).

```
------------------------------ SD 5 -----------------------------
!                                                                !
!  1 : Print input table on screen                               !
!  2 : Print input table on printer                              !
!  3 : Plot catch curve on screen                                !
!  4 : Plot catch curve on printer                               !
!  5 : Print results of catch analysis on screen                 !
!  6 : Print results of catch analysis on printer                !
!  7 : Print details of regression analysis on screen            !
!  8 : Print details of regression analysis on printer           !
!  9 : Redo analysis with same input data                        !
!                                   (e.g. with new v.B. param.)  !
! 10 : Print all results on PRINTER (Options 2,4,6 and 8)        !
! 11 : Quit (continue with estimation of SELECTION OGIVE)        !
!                                                                !
! Choose option (default = 1,3 and 5) !RETURN!                   !
!                                                                !
------------------------------ SD 5 -----------------------------
```

Option 11 in SD 5 continues the analysis with the estimation of selection parameters, i. e. the regression analysis :

$$Y(j) = s1 - s2 * X(j), \quad j = j3,j3+1,...,j4.$$

where X(j) is the age (defined as for the catch curve)

$$Y(j) = \log q(j)$$

where

$$q(j) = \exp(A + B * X(j)) * dt(j)/C(j) - 1$$

dt(j) and C(j) are defined as for the catch curve analysis. A and B are the intercept and the slope respectively from the catch curve analysis.

The ages of 50 % and 75 % selection are estimated by :

$$A50\% = - s1/s2$$

$$A75\% = A50\% - \log(3)/s2$$

and the corresponding lengths are determined by the von Bertalanffy equantion with t-zero given as input as shown in SD 10. Further explanations on the selection model is given in Section 3.14.6.

SD 6

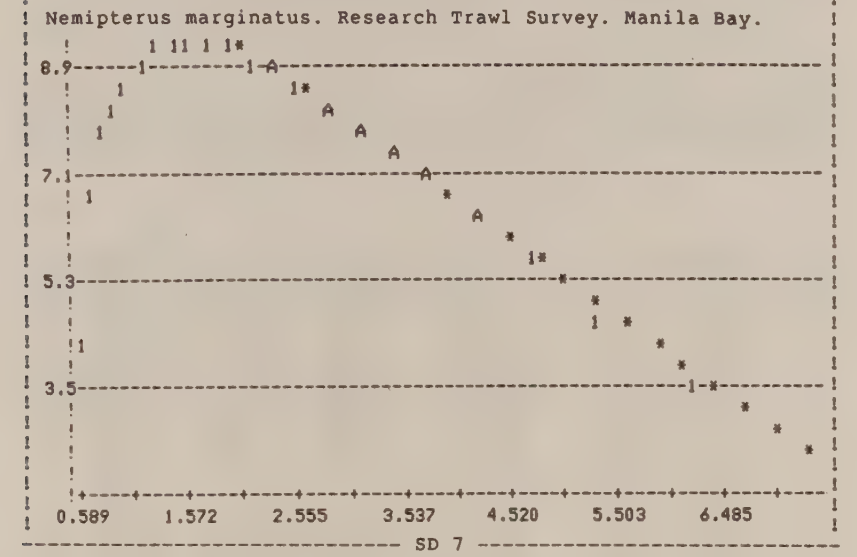
Interval	C		dt	t	log(C/dt)
6.00- 7.00	7.00	I	0.1064	0.6105	4.1864
7.00- 8.00	91.00	I	0.1111	0.7192	6.7079
8.00- 9.00	355.00	I	0.1163	0.8328	8.0237
9.00- 10.00	551.00	I	0.1219	0.9519	8.4156
10.00- 11.00	758.00	I	0.1282	1.0769	8.6845
11.00- 12.00	1113.00	I	0.1351	1.2085	9.0160
12.00- 13.00	1473.00	I	0.1429	1.3475	9.2407
13.00- 14.00	1856.00	I	0.1515	1.4946	9.4129
14.00- 15.00	2077.00	I	0.1613	1.6509	9.4628
15.00- 16.00	2106.00	I	0.1724	1.8176	9.4100
16.00- 17.00	2010.00	I	0.1852	1.9962	9.2918
17.00- 18.00	1852.00	I	0.2001	2.1886	9.1329
18.00- 19.00	1653.00	I	0.2175	2.3971	8.9357
19.00- 20.00	1417.00	I	0.2382	2.6245	8.6906
20.00- 21.00	1158.00	I	0.2634	2.8747	8.3885
21.00- 22.00	899.00	I	0.2944	3.1528	8.0239
22.00- 23.00	660.00	I	0.3338	3.4657	7.5893
23.00- 24.00	452.00	I	0.3853	3.8234	7.0672
24.00- 25.00	284.00	I	0.4558	4.2411	6.4346
25.00- 26.00	164.00	I	0.5578	4.7428	5.6835
26.00- 27.00	84.00	I	0.7192	5.3710	4.7604
27.00- 28.00	40.00	I	1.0136	6.2122	3.6753
28.00- 29.00	12.00	I	1.7328	7.4893	1.9351

SD 6

The regression range is defined by :

j3 is the smallest index for which C(j3),C(j3+1),...,C(j4) are all positive (> 0). j4 is the largest index less than j1 (the lower limit for the range used in the catch curve analysis) for which q(j) is positive.

SD 7



SD 7

SD 8

- - LENGTH CONVERTED CATCH CURVE ANALYSIS - -

Nemipterus marginatus. Research Trawl Survey. Manila Bay.

Estimate of Z 1.320246

Standard deviation of Z 0.038647
Confidence limits of Z (1.21899 , 1.42150)

These values were obtained with the growth parameters :

L-infinity 30
K 0.4

First length group used in the analysis 16 - 17
Last length group used in the analysis 26 - 27

Number of length groups used : 11

Regression weighted by square root of numbers

SD 8

```
------------------------------ SD 9 -------------------------------
!                                                                  !
! RESULTS OF THE REGRESSION ANALYSIS                               !
!                                                                  !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay.        !
!                                                                  !
! Number of observations  11                                       !
!                                                                  !
!  Intercept  a            12.0782046                              !
!  std. dev. of intercept  .209579119                              !
!  Confidence interval of intercept 11.5291073 - 12.6273018        !
!                                                                  !
!  Slope      b            -1.32024658                             !
!  std. dev. of slope      .0386471947                             !
!  Confidence interval of slope     -1.42150223 - -1.21899093      !
!                                                                  !
!  Mean value of x's       2.92467078                              !
!  Std. dev. of x's        4.78950179                              !
!  Mean value of y's       8.21691797                              !
!  Std. dev. of y's        6.34765933                              !
!                                                                  !
!  Correlation coeff.  r   -.996166147                             !
!                      r*r  .992346993                             !
!  Confidence interval of r         -.999039807 - -.984757799      !
!                                                                  !
!  Regression weighted by square root of numbers                   !
!                                                                  !
------------------------------ SD 9 -------------------------------
```

```
------------------------------ SD 10 ------------------------------
!                                                                  !
!       - - LENGTH CONVERTED CATCH CURVE ANALYSIS - -              !
!                                                                  !
!                    SELECTION ANALYSIS                            !
!                                                                  !
!        Give t-zero, default = 0  !RETURN!                        !
!                                                                  !
------------------------------ SD 10 ------------------------------
```

The menu in SD 11 offers two different displays of results either on screen or on printer.

Option 3 and 4 produce a display similar to SD 9. The display produced by option 1 is shown in SD 12.

The menu in SD 11 offers you the option to redo the analysis (option 5). If this option is chosen you return to SD 1.

```
------------------------------ SD 11 ------------------------------
!                                                                  !
!  1 : Print selection results on screen                           !
!  2 : Print selection results on printer                          !
!  3 : Print details of regression analysis on screen              !
!  4 : Print details of regression analysis on printer             !
!  5 : Redo analysis with same input data                          !
!  5 : Redo analysis with new data set                             !
!  7 : Quit (return to main menu)                                  !
!                                                                  !
! Choose option (default = 1 )  !RETURN!                           !
!                                                                  !
------------------------------ SD 11 ------------------------------
```

```
------------------------------ SD 12 ------------------------------
!                                                                  !
! Nemipterus marginatus. Research Trawl Survey. Manila Bay.        !
!                                                                  !
!    SELECTION ANALYSIS                                            !
!                                                                  !
!    Interval              C          dt        t      Sel. ogive !
! ---------------------------------------------------------------- !
!    6.00-  7.00          7.00  I    0.1064    0.6105     0.0162  !
!    7.00-  8.00         91.00  I    0.1111    0.7192     0.0264  !
!    8.00-  9.00        355.00  I    0.1163    0.8328     0.0435  !
!    9.00- 10.00        551.00  I    0.1219    0.9519     0.0726  !
!   10.00- 11.00        758.00  I    0.1282    1.0769     0.1215  !
!   11.00- 12.00       1113.00  I    0.1351    1.2085     0.2012  !
!   12.00- 13.00       1473.00  I    0.1429    1.3475     0.3217  !
!   13.00- 14.00       1856.00  I    0.1515    1.4946     0.4810  !
!                      Tc (=T50%) =   1.5112  LC (=L50%) =  13.6096 !
!   14.00- 15.00       2077.00  I    0.1613    1.6509     0.6538  !
!   15.00- 16.00       2106.00  I    0.1724    1.8176     0.8014  !
!                      T75% =         1.7524  L75% =       15.1172 !
! ---------------------------------------------------------------- !
!   16.00- 17.00       2010.00  I    0.1852    1.9962     0.9010  !
!   17.00- 18.00       1852.00  I    0.2001    2.1886     0.9562  !
!   18.00- 19.00       1653.00  I    0.2175    2.3971     0.9826  !
!   19.00- 20.00       1417.00  I    0.2382    2.6245     0.9937  !
!   20.00- 21.00       1158.00  I    0.2634    2.8747     0.9980  !
!                                                                  !
!   21.00- 22.00        899.00  I    0.2944    3.1528     0.9994  !
!   22.00- 23.00        660.00  I    0.3338    3.4657     0.9998  !
!   23.00- 24.00        452.00  I    0.3853    3.8234     1.0000  !
!   24.00- 25.00        284.00  I    0.4558    4.2411     1.0000  !
!   25.00- 26.00        164.00  I    0.5578    4.7428     1.0000  !
!   26.00- 27.00         84.00  I    0.7192    5.3710     1.0000  !
!   27.00- 28.00         40.00  I    1.0136    6.2122     1.0000  !
!   28.00- 29.00         12.00  I    1.7328    7.4893     1.0000  !
!                                                                  !
------------------------------ SD 12 ------------------------------
```

3.14.4. PRINTER OUTPUT.

Printer output is very similar to the screen displays SD 3, SD 6, SD 7, SD 8, SD 9 and SD 12.

3.14.5. CONNECTIONS TO OTHER PROGRAMS.

CCURVE does not produce disk output which can act as input to other programs.

The estimated selection parameters may be applied to adjust for selection in the Bhattacharya analysis (BHATTAC).

3.14.6.THEORY (SELECTION ANALYSIS).

The regression analysis used for the selection analysis is derived the following way :

From the catch curve equation for the fully exploited length groups :

$$\log(C(j)/dt(j)) = A + B\,X(j) \quad , \quad j = j1,j1+1,\ldots,j2.$$

if follows that

$$C(j) = dt(j)\,\log(A + B\,X(j)) \quad , \quad j = j1,j1+1,\ldots,j2.$$

This expression is used to predict the catch, Cp, in the small length groups j = j3,j3+1,...,j4 if these length groups had been under full exploitation (assuming Z = - B to remain constant for all length groups) :

$$Cp(j) = dt(j)\,\log(A + B\,X(j)) \quad , \quad j = j3,j3+1,\ldots,j4.$$

The fraction selected (the selection ogive) is estimated by

$$C(j)/Cp(j) \quad , \quad j = j3,j3+1,\ldots,j4.$$

Thus, using the logistic curve to model selection :

$$C(j)/Cp(j) = 1/(1 + \exp(s1 - s2*X(j))) \quad , \quad j = j3,j3+1,\ldots,j4.$$

which is equivalent to :

$$\log(\exp(A + B*X(j))*dt(j)/C(j) - 1) = s1 - s2*X(j) \qquad j = j3,j3+1,\ldots,j4.$$

i.e. the regression equation applied by CCURVE.

The regression coefficients, s1 and s2 give the selection ages:

$$A50\% = -\,s1/s2 \quad , \quad A75\% = A50\% - \log(3)/s2$$

from which the corresponding lengths are derived :

$$L50\% = L8*(1-\exp(K*(A50\%-to)) \quad , \quad L75\% = L8*(1-\exp(K*(A75\%-to))$$

3.15. BHZWET.

3.15.1. PURPOSE.

The program BHZWET contains two separate analyses, which can be used independently. Both models use length composition data as input. The two models are put together because they are derived from the same basic model.

One part of the program uses the Beverton and Holt (1956) Z-equation, which estimates Z assuming that L8 (L-infinity) and K (curvature parameter) are known from :

$$Z = K \frac{L8 - L}{L - L'}$$

where L' is a length from which and onwards the fish are under full exploitation and L is the mean length of all fish of length L' and longer.

The other part of the program uses a modified version of a method developed by Wetherall, Polovina and Ralston (in press) which estimates L8 and Z/K.

This method uses a linear regression analysis :

$$Y(i) = a + b\ X(i)$$

where $Y(i) = L - L(i)$ and $X(i) = L(i)$

L(i) (lower limit of length group no. i) plays the same role a L' in the Beverton and Holt Z-equation).

From the regression coefficients a and b, estimates of Z/K and L8 are derived :

$$Z/K = -(1+b)/b \quad \text{and} \quad L8 = -a/b$$

The latter method may be considered a special application of the Beverton and Holt Z-equation (from which it is easily derived). The method is explained in Wetherall, 1986.

3.15.2. INPUT / INPUT FILE.

The input file must be of the type:

" weighted sum of length frequencies"

i.e. produced by option 1 of the program LFMANI.
The data used as an example is the same data set as used in the length converted catch curve program, CCURVE, (Table 3.14.2.1 in the manual for CCURVE).

3.15.3. SCREEN DIALOGUE.

After retrieval of the input data file SD 1 follows, where you are asked which of the two methods you want to apply.

```
------------------------------ SD 1 -------------------------------
!                                                                  !
!  - - BEVERTON AND HOLT : Z = K*(L8 - Lmean)/(Lmean - L') - -     !
!                                                                  !
!               - - WETHERALL ET. AL. METHOD - -                   !
!                                                                  !
!  1: Beverton and Holt : Z = K*(L8-Lmean)/Lmean-L')               !
!                                                                  !
!  2: Modified Wetherall et. al. method : Lmean - L' = a + b*L'    !
!                                                                  !
!     Choose option   ! 1 !                                        !
!                                                                  !
------------------------------ SD 1 -------------------------------
```

Beverton and Holt Z-equation.

Option 1 in SD 1 gives the Beverton and Holt Z-equation.
In SD 2 you are asked to enter the von Bertalanffy growth parameters L8 and K.
When the input has been confirmed the results are displayed as shown in SD 3.

```
------------------------------ SD 2 -------------------------------
!                                                                  !
!  - - BEVERTON AND HOLT : Z = K*(L8 - Lmean)/(Lmean - L') - -     !
!                                                                  !
!  Length range            6 - 28                                  !
!                                                                  !
! Give L-infinity              ! 30 !                              !
!                                                                  !
! Give K , default = 1         ! 0.4!                              !
!                                                                  !
! Is input ok ? (y/n) default = y                                  !
!                                                                  !
------------------------------ SD 2 -------------------------------
```

SD 3 shows the input (catch in numbers), for each length group and the mean length of the catch of all fish above the lower class limit of that particular length group.

For each length group an estimate of Z is calculated using the Beverton and Holt equation

$$Z = K*(L8-Lmean)/(Lmean-L')$$

where K and L8 are the input values and L' is the lower class limit of the length group and Lmean is the mean length of all fish larger than L' in the catch.

```
---------------------------- SD 3 -------------------------------
!                                                               !
!  - - BEVERTON AND HOLT : Z = K*(L8 - Lmean)/(Lmean - L') - -  !
!                                                               !
! Nemipterus marginatus. Research trawl survey. Manila Bay.     !
!    L(j)-L(j+1)   C(j)        Lmean          Z                !
!    ------------------------------------------                 !
!      6- 7          7  I       16.2823       0.5336          !
!      7- 8         91  I       16.2855       0.5907          !
!      8- 9        355  I       16.3236       0.6572          !
!     9-10         551  I       16.4583       0.7262          !
!     10-11        758  I       16.6494       0.8031          !
!     11-12       1113  I       16.8908       0.8901          !
!     12-13       1473  I       17.2205       0.9791          !
!     13-14       1856  I       17.6363       1.0666          !
!     14-15       2077  I       18.1526       1.1411          !
!     15-16       2106  I       18.7458       1.2018          !
!     16-17       2010  I       19.3855       1.2541          !
!     17-18       1852  I       20.0541       1.3026          !
!     18-19       1653  I       20.7474       1.3471          !
!     19-20       1417  I       21.4659       1.3843          !
!     20-21       1158  I       22.2082       1.4114          !
!     21-22        899  I       22.9705       1.4269          !
!     22-23        660  I       23.7500       1.4285          !
!     23-24        452  I       24.5463       1.4107          !
!     24-25        284  I       25.3561       1.3697          !
!     25-26        164  I       26.1666       1.3142          !
!     26-27         84  I       26.9705       1.2484          !
!     27-28         40  I       27.7307       1.2421          !
!     28-29         12  I       28.5000       1.2000          !
! Do you want the table printed, (y/n), default = n !RETURN!    !
!                                                               !
---------------------------- SD 3 -------------------------------
```

Valid estimates of Z are only obtained when L' corresponds to a length where the stock is fully recruited to the fishery. In this example the stock is assumed to be fully recruited to the fishery at a length around 16 cm, (compare the manual for CCURVE).

Reasonable estimates of Z can be found in rows corresponding to length classes above 16 cm.

Length classes close to L8 should not be used because of the relatively few fish in these length groups and because of the uncertain relationship between age and length of old fish.

Summarizing, only few rows in the Z column give reasonable estimates of Z, but the program leaves the decision to the user.

Finally it should be mentioned that in case K (curvature parameter) is unknown you may choose the default value of K = 1. In this case the estimate of Z printed in SD 3 will actually be an estimate of Z/K. However the heading of the column in SD 3 will still show K.

After SD 3 follows the menu SD 1, and you may try a new Beverton and Holt Z-equation using alternative estimates of the growth parameters.

Modified Wetherall et. al. method.

Option 2 in the SD 1 menu activates the Wetherall et.al. method and produces SD 4.

The modified Wetherall et. al. method is based on a plot of Lmean-L' against L', i. e. the regression analysis :

$$Y(i) = a + b\,X(i)$$

where $Y(i) = Lmean(i) - L(i)$ and $X(i) = L(i)$

L(i) is the lower class limit of length group no. i and Lmean(i) is the mean length of all fish larger than L(i) in the catch

$$Lmean(i) = \sum_{L(j)>L(i)} C(j)*0.5*(L(j)+L(j+1)) \Big/ \sum_{L(j)>L(i)} C(j)$$

From the slope, b and the intercept, a the estimates

$Z/K = -(1+b)/b$ and $L8 = a/b$ are obtained.

Usually the points corresponding to small values of L(i) will deviate systematically from the fitted line because these fish are not yet fully recruited to the fishery.
A straight line is observed only when all length groups are under full exploitation.
The method assumes Z to remain constant for length groups under full exploitation. Therefore it may be necessary to exclude points corresponding to small length groups.

SD 4 shows the length frequency distribution of the catch and the length range to be used in the regression is entered in SD 4. (this is the same display as SD 4 in the manual for CCURVE).

You may scroll through SD 4 by repeatedly using the RETURN-key.
You may suppress the listing by entering 'e'.
Another option, 's' is to get a graph of the frequency distribution of the catch (this graph is identical to SD 3 in the manual for CCURVE).

```
---------------------------- SD 4 -----------------------------
!                                                             !
! SELECT RANGE OF LENGTHS TO BE USED IN ANALYSIS              !
! Look at the data below                                      !
!                                                             !
! If you want plot on screen enter 's'                        !
! If you want plot on printer enter 'p'                       !
!                                                             !
!                                (option : 'e' to end looking over) !
! Index    Interval          frequency                        !
! ------------------------------------                        !
!   1     6.00 -  7.00          7  I                          !
!   2     7.00 -  8.00         91  I                          !
!   3     8.00 -  9.00        355  I                          !
!   4     9.00 - 10.00        551  I                          !
!   5    10.00 - 11.00        758  I                          !
!   6    11.00 - 12.00       1113  I                          !
!   7    12.00 - 13.00       1473  I                          !
!   8    13.00 - 14.00       1856  I                          !
!   9    14.00 - 15.00       2077  I                          !
!  10    15.00 - 16.00       2106  I                          !
!  11    16.00 - 17.00       2010  I                          !
!  12    17.00 - 18.00       1852  I                          !
!  13    18.00 - 19.00       1653  I                          !
!  14    19.00 - 20.00       1417  I                          !
!  15    20.00 - 21.00       1158  I                          !
!  16    21.00 - 22.00        899  I                          !
!  17    22.00 - 23.00        660  I                          !
!  18    23.00 - 24.00        452  I                          !
!  19    24.00 - 25.00        284  I                          !
!  20    25.00 - 26.00        164  I                          !
!  21    26.00 - 27.00         84  I                          !
!  22    27.00 - 28.00         40  I                          !
!  23    28.00 - 29.00         12  I                          !
!                                                             !
!  Give index of first length group in reg. analysis ! 11 !   !
!  Give index of last length group in reg. analysis  ! 21 !   !
!                                                             !
!  Is input ok ? (y/n) default = y  !RETURN!                  !
!                                                             !
---------------------------- SD 4 -----------------------------
```

Having selected the range SD 5 gives you a menu for presentation of the results of the analysis.

The options for the printer produce the same output as those for the screen.

```
------------------------------ SD 5 -------------------------------
!                                                                  !
!          - - WETHERALL ET. AL. METHOD - -                        !
!                                                                  !
!        1: Print input table on screen                            !
!        2: Print input table on printer                           !
!        3: Plot on screen                                         !
!        4: Plot on printer                                        !
!        5: Print results on screen                                !
!        6: Print results on printer                               !
!        7: Print details of regression analysis on screen         !
!        8: Print details of regression analysis on printer        !
!        9: Redo analysis with the same input data                 !
!       10: Print all results on PRINTER (options 2,4,6,8)         !
!       11: Quit (Return to main menu)                             !
!                                                                  !
!       Choose option ( default = 1,3,5 ) !RETURN!                 !
!                                                                  !
------------------------------ SD 5 -------------------------------
```

The effect of the default options (1,3 and 5) are shown in SD 6, SD 7 and SD 8.

The lines in SD 6 indicate the length range used in the regression analysis.

The symbols used on the graph (SD 7) mean :

1: One observation (L-L',L')
2: Two observations (L-L',L')
... etc. ...

*: The regression line.

A: One observation (L-L',L') on the regression line
B: Two observations (L-L',L') on the regression line
... etc. ...

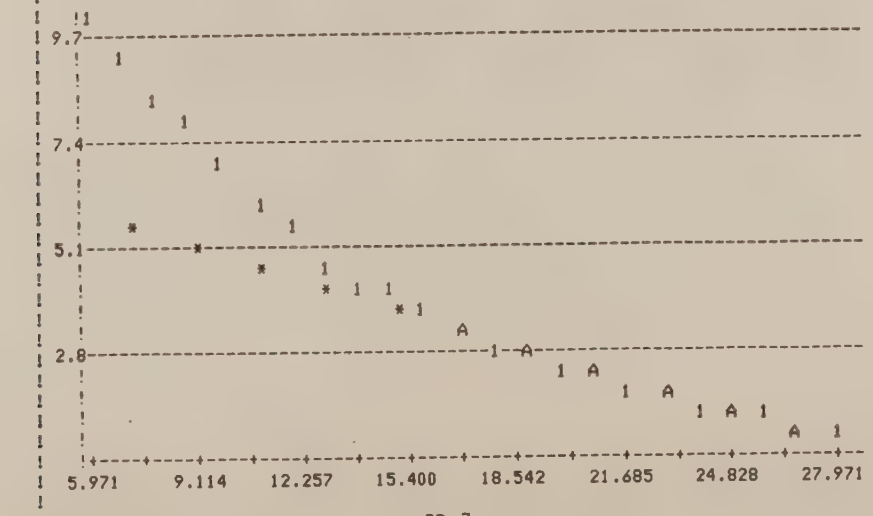
SD 6

Interval	C		Lmean	L'=X	Lmean-L'=Y
6- 7	7	I	16.2823	6.0000	10.2823
7- 8	91	I	16.2855	7.0000	9.2855
8- 9	355	I	16.3236	8.0000	8.3236
9-10	551	I	16.4583	9.0000	7.4583
10-11	758	I	16.6494	10.0000	6.6494
11-12	1113	I	16.8908	11.0000	5.8908
12-13	1473	I	17.2205	12.0000	5.2205
13-14	1856	I	17.6363	13.0000	4.6363
14-15	2077	I	18.1526	14.0000	4.1526
15-16	2106	I	18.7458	15.0000	3.7458
16-17	2010	I	19.3855	16.0000	3.3855
17-18	1852	I	20.0541	17.0000	3.0541
18-19	1653	I	20.7474	18.0000	2.7474
19-20	1417	I	21.4659	19.0000	2.4659
20-21	1158	I	22.2082	20.0000	2.2082
21-22	899	I	22.9705	21.0000	1.9705
22-23	660	I	23.7500	22.0000	1.7500
23-24	452	I	24.5463	23.0000	1.5463
24-25	284	I	25.3561	24.0000	1.3561
25-26	164	I	26.1666	25.0000	1.1666
26-27	84	I	26.9705	26.0000	0.9705
27-28	40	I	27.7307	27.0000	0.7307
28-29	12	I	28.5000	28.0000	0.5000

SD 6

SD 7

Nemipterus marginatus. Research trawl survey. Manila Bay.



SD 7

```
---------------------------- SD 8 -----------------------------
!                                                             !
!            - - WETHERALL ET. AL. METHOD - -                 !
!                                                             !
! Nemipterus marginatus. Research trawl survey. Manila Bay.   !
!                                                             !
! Estimate of L8           29.66866                           !
!                                                             !
! Estimate of Z/K           3.21524                           !
!                                                             !
! First length group used in the analysis  16 - 17            !
! Last length group used in the analysis   26 - 27            !
!                                                             !
! Number of length groups used : 11                           !
!                                                             !
---------------------------- SD 8 -----------------------------
```

The analysis may be redone on the same dataset, but with a new range of points in the regression (option 9 in SD 5 brings you back to SD 2).

3.15.4. PRINTER OUTPUT.

Option 10 in SD 5 the total output on the printer corresponding to SD 6, SD 7, SD 8 and the standard output on details of the regression (same format as SD 9 in the manual for CCURVE). If you only want a part of the output SD 5 offers options for that as well.

3.15.5. CONNECTION TO OTHER PROGRAMS.

The program BHZWET does not produce files used by other programs.

3.16. JONZAL.

3.16.1. PURPOSE.

The purpose of the program JONZAL is to estimate Z, the total mortality, using the cumulated catch curve technique (Jones and van Zalinge, 1982). The method is discussed in Jones, 1984.

The method applies the linear regression :

$$Y(j) = a + b*X(j), \quad j = 1,2,...,n \text{ where}$$

$Y(j) = \log(C(L(j),L8))$

$X(j) = \log(L8 - L(j))$

$L(j)$ = Lower limit of length group j

$L8$ = Von Bertalanffy parameter (L-infinity)

$C(L(j),L8))$ = Cumulated catch = $\sum_{i=j}^{n} C(i)$

$C(i)$ = number caught in length group no. i.

The estimated slope b in the regression is an estimate of Z/K.

Thus, input to the Jones and van Zalinge analysis is

$C(i)$, $i = 1,2,...,n$, and $L8$

To estimate Z rather that Z/K , K must be given as input. In case only L8 is known, K=1 may be used as input and in that case Z/K is estimated.

The Jones and van Zalinge method may be considered an alternative to the length convertd catch curve analysis (the program CCURVE) and the choice between the two is left to the user. It should be noticed, however, that estimation of selection ogives is not possible by the program JONZAL.

3.16.2. INPUT / INPUT FILE.

Input data must be of the type:

" weighted sum of length frequencies"

i.e. produced by option 1 of the program LFMANI.

The data used as example is the same data as used in the manuals for the programs CCURVE and BHZWET (see Table 2.1 in the manual for CCURVE).

3.16.3. SCREEN DIALOGUE.

After retrieval of the input data file SD 1 follows and you are asked to enter the values of L8 and K.

```
---------------------------- SD 1 -----------------------------
!                                                             !
!       - - JONES AND VAN ZALINGE METHOD - -                  !
!                                                             !
!   Length range          6 - 28                              !
!                                                             !
!   Default value : 'return'                                  !
!                                                             !
!   Give  L-infinity      0      ! 30 !                       !
!                                                             !
!   Give K                1      ! .4 !                       !
!                                                             !
!   Is input ok ? (y/n) default = y   !RETURN!                !
!                                                             !
---------------------------- SD 1 -----------------------------
```

If L8 is chosen to be smaller than the longest length group all length groups above L8 will be excluded from the analysis. (The argument L8-L(j) in the logarithm must be positive).

The next step in the procedure is to choose the points to be used in the regression as shown in SD 2.

When considering the plot of Y(j) and X(j) systematic deviations from linearity are usually observed for small and for large length groups, and a range of points to be included in the regression must be selected.
Small fish should be excluded because they are not under full expolitation and large fish should be excluded because the relationship between length and age is uncertain for old specimens.

You may scroll through SD 2 by repeatedly using the RETURN-key.

The listing can be suppressed by 'e'.

Other options, 's' and 'p' produce a graph of the frequency distribution of the catch, as shown in the manual to CCURVE (SD 3 in the manual to CCURVE).

Having selected the range in SD 2 the calculations will be performed and followed by the menu in SD 3.

The results of the default options (1, 3 and 5) in SD 3 are shown in SD 4, SD 5 and SD 6.

```
---------------------------- SD 2 -----------------------------
!                                                             !
! SELECT RANGE OF LENGTHS TO BE USED IN ANALYSIS              !
! Look at the data below                                      !
!                                                             !
! If you want plot on screen enter 's'                        !
! If you want plot on printer enter 'p'                       !
!                              (option : 'e' to end looking over) !
! Index    Interval        frequency                          !
! ------------------------------------                        !
!   1     6.00 -  7.00          7  I                          !
!   2     7.00 -  8.00         91  I                          !
!   3     8.00 -  9.00        355  I                          !
!   4     9.00 - 10.00        551  I                          !
!   5    10.00 - 11.00        758  I                          !
!   6    11.00 - 12.00       1113  I                          !
!   7    12.00 - 13.00       1473  I                          !
!   8    13.00 - 14.00       1856  I                          !
!   9    14.00 - 15.00       2077  I                          !
!  10    15.00 - 16.00       2106  I                          !
!  11    16.00 - 17.00       2010  I                          !
!  12    17.00 - 18.00       1852  I                          !
!  13    18.00 - 19.00       1653  I                          !
!  14    19.00 - 20.00       1417  I                          !
!  15    20.00 - 21.00       1158  I                          !
!  16    21.00 - 22.00        899  I                          !
!  17    22.00 - 23.00        660  I                          !
!  18    23.00 - 24.00        452  I                          !
!  19    24.00 - 25.00        284  I                          !
!  20    25.00 - 26.00        164  I                          !
!  21    26.00 - 27.00         84  I                          !
!  22    27.00 - 28.00         40  I                          !
!  23    28.00 - 29.00         12  I                          !
!                                                             !
!  Give index of first length group in reg. analysis ! 11 !   !
!  Give index of last length group in reg. analysis  ! 21 !   !
!                                                             !
!  Is input ok ? (y/n) default = y  !RETURN!                  !
---------------------------- SD 2 -----------------------------

---------------------------- SD 3 -----------------------------
!                                                             !
!    - -  JONES AND VAN ZALINGE METHOD - -                    !
!                                                             !
!   1: Print input table on screen                            !
!   2: Print input table on printer                           !
!   3: Plot on screen                                         !
!   4: Plot on printer                                        !
!   5: Print results on screen                                !
!   6: Print results on printer                               !
!   7: Print details of regression analysis on screen         !
!   8: Print details of regression analysis on printer        !
!   9: Redo analysis with the same input data                 !
!                  (e.g. with new v. B. param.)               !
!  10: Print all results on PRINTER (options 2,4,6,8)         !
!  11: Quit (Return to main menu)                             !
!                                                             !
!      Choose option ( default = 1,3,5 ) !RETURN!             !
---------------------------- SD 3 -----------------------------
```

SD 4

Nemipterus marginatus. Research trawl survey. Manila Bay.

Interval		C	Cum.C	log(L8-L)	log(Cum.C)	Z	Conf. interval	
6.00-	7.00	7.00	21072.00	3.1780	9.9557			
7.00-	8.00	91.00	21065.00	3.1355	9.9553			
8.00-	9.00	355.00	20974.00	3.0910	9.9510			
9.00-	10.00	551.00	20619.00	3.0445	9.9339			
10.00-	11.00	758.00	20068.00	2.9957	9.9068			
11.00-	12.00	1113.00	19310.00	2.9444	9.8683			
12.00-	13.00	1473.00	18197.00	2.8902	9.8090			
13.00-	14.00	1856.00	16724.00	2.8332	9.7246			
14.00-	15.00	2077.00	14868.00	2.7725	9.6069			
15.00-	16.00	2106.00	12791.00	2.7080	9.4565			
16.00-	17.00	2010.00	10685.00	2.6390	9.2766	1.411	1.372	1.450
17.00-	18.00	1852.00	8675.00	2.5649	9.0682	1.426	1.398	1.453
18.00-	19.00	1653.00	6823.00	2.4849	8.8280	1.438	1.417	1.460
19.00-	20.00	1417.00	5170.00	2.3979	8.5506	1.449	1.433	1.464
20.00-	21.00	1158.00	3753.00	2.3025	8.2303	1.456	1.443	1.469
21.00-	22.00	899.00	2595.00	2.1972	7.8613	1.459	1.442	1.476
22.00-	23.00	660.00	1696.00	2.0794	7.4360	1.458	1.431	1.485
23.00-	24.00	452.00	1036.00	1.9459	6.9431	1.451	1.402	1.499
24.00-	25.00	284.00	584.00	1.7917	6.3699			
25.00-	26.00	164.00	300.00	1.6094	5.7037			
26.00-	27.00	84.00	136.00	1.3863	4.9126			
27.00-	28.00	40.00	52.00	1.0986	3.9512			
28.00-	29.00	12.00	12.00	0.6931	2.4849			

SD 4

SD 4 shows the input data together with the data for the plot. The selected range of points for the regression are indicated with lines in SD 4.

The estimate of Z, and the lower and upper confidence limit for Z, are shown in the row giving the smallest length group in the selected range for the regression.
In the example the estimate of Z based on points in the range from 6-17 to 26-27 is 1.4110.
Additional estimates of Z are given for successively smaller ranges of points in the regression. The estimate based on the points in the range from 17-18 to 26-27 is 1.4259.

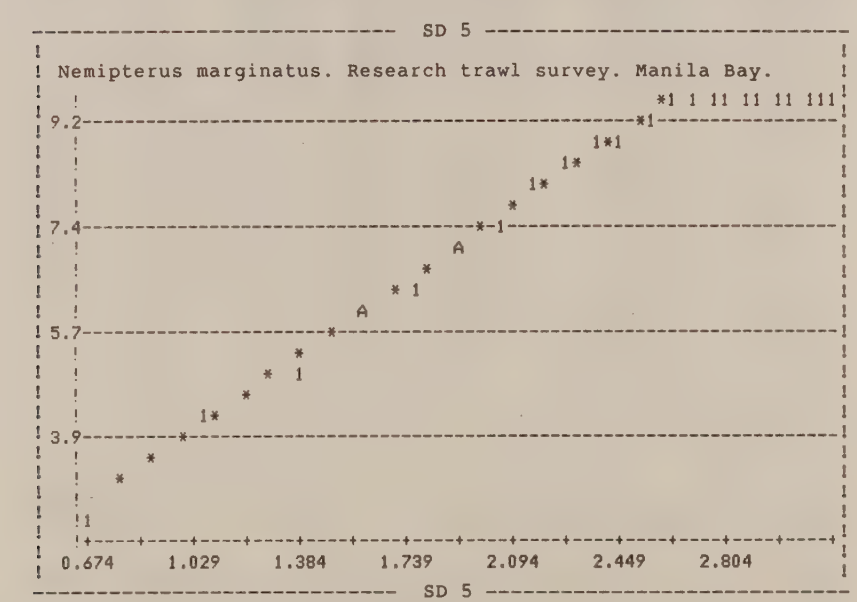
The minimum number of points used is 4, and the last estimate given in this example is thus based on points in the range from 23-34 to 26-27.

The confidence limits of Z are given by :

$$b*K + t(n-2)*K*s$$

where b (=Z/K) is the slope of the reression line and s is the standard deviation of b and t(x) is the student's statistics with x degrees of freedom (compare the manual for program REGRES).

Option 3 in SD 3 produces SD 5 which shows the plot of the points and the fitted line in the range selected (from 16-17 to 26-27)



The symbols used on the graph (SD 5) mean :

1 : One observation of (log(L8-L), log(Cum.C))
2 : Two observations of (log(L8-L), log(Cum.C))
... etc. ...

* : The regression line

A : One observation of (log(L8-L), log(Cum.C)) on the reg. line
B : Two observations of (log(L8-L), log(Cum.C)) on the reg. line
... etc. ...

SD 6 (from option 5 in SD 3) shows the result and summarises the values of growth parameters used in the estimation and the selected range.

Option 7 in SD 3 gives the details of the regression analysis (similar to SD 9 in the manual for CCURVE).

```
--------------------------- SD 6 ---------------------------
!                                                          !
!       - - JONES AND VAN ZALINGE ANALYSIS - -             !
!                                                          !
! Nemipterus marginatus. Research trawl survey. Manila Bay.!
!                                                          !
! Z =   1.411007                                          !
!                                                          !
! Confidence interval  1.37196 - 1.45005                   !
!                                                          !
! This result was obtained for the parameters :            !
! L8 =   30                                                !
! K  =   0.4                                               !
!                                                          !
! First length group used   16 - 17                        !
! Last length group used    26 - 27                        !
! Number of length groups used  11                         !
!                                                          !
--------------------------- SD 6 ---------------------------
```

Option 9 in SD 3 offers the option of a new analysis of the data set using new von Bertalanffy parameters and/or a new range of points used in the regression.
Selection of this option will make SD 1 appear and the procedure may be repeated.

3.16.4. PRINTER OUTPUT.

Printer output is available in the SD 3 menu. Choosing the oppropriate options produces similar tables and graphs to those shown in SD 4, SD 5 and SD 6.

3.16.5. CONNECTION TO OTHER PROGRAMS.

JONZAL does not produce files used as input for other programes.

3.17. LCOHOR.

3.17.1. PURPOSE.

The purpose of the program LCOHOR is to perform the length based cohort analysis developed by R. Jones, 1974. A detailed description is given in Jones, 1984 and Sparre, 1985.

Ideally, the method requires the length composition of the catch in numbers of a cohort during its entire life span. In addition, estimates of the von Bertalanffy growth parameters K and L8 and an estimate of natural mortality M must be available.

Most often, the numbers caught during the life span of a cohort are difficult to obtain. The catch during the life span of a cohort is therefore often estimated by the total catch of all cohorts during one year. This approach is strictly correct only if recruitment (and all other parameters in the system) have remained constant. It is therefore advisable to use the average catch numbers during a number of years (see Jones 1984 or Sparre 1985).

Using these input data the method estimates fishing mortality and population size by length group, using the formulae :

$$N(L1) = (N(L2)*X(L1,L2) + C(L1,L2))*X(L1,L2)$$

$$N(\text{last group}) = C(\text{last group})/(\text{Terminal E})$$

(Notice that the last length group is a plus group)

$$F(L1,L2) = M*E(L1,L2)/(1-E(L1,L2))$$

Where (L1,L2) = (lower limit, upper limit) of a length group

N(L1) = stock number attaining length L1

C(L1,L2) = number of fish caught between lengths L1 and L2

M = natural mortality

$$X(L1,L2) = ((L8-L1)/(L8-L2))^{M/2K}$$

L8, K = von Bertalanffy parameters

F(L1,L2) = fishing mortality

E(L1,L2) = F(L1,L2)/(M+F(L1,L2)) = exploitation rate

In addition LCOHOR converts the estimated stock numbers into biomasses using a length weight relationship (given as input) :

$$\text{Biomass} = \sum_{\text{all lengths}} N(L1,L2)*q*((L1+L2)/2)^{b}$$

and it calculates the weighted mean F value :

$$\text{Mean F} = \sum_{\text{all lengths} > Lu} N(L1,L2)*F(L1,L2) \;/\; \sum_{\text{all lengths} > Lu} N(L1,L2)$$

i.e. the mean F for all fish longer than Lu weighted by stock numbers

3.17.2. INPUT / INPUT FILE.

The input file must be of the type :

"weighted sum of length frequencies"

i.e. it can be produced by option 1 of the program LFMANI.

The example used here is the same as the one used for the length converted catch curve (see Table 3.14.2.1. in the manual for CCURVE). This example was also used in the manuals for BHZWET and JONZAL.

3.17.3. SCREEN DIALOGUE.

After retrieval of the data file SD 1 appears, and you are asked to give the values of the von Bertalanffy parameters L8 (L-infinity), the curvature parameter K and the value of natural mortality M.
Finally, to run the length cohort analysis you enter the terminal exploitation rate F/Z.

The three following input parameters (q,b and first length for mean F) are used for calculation of biomasses and mean F (cf. Section 3.17.1).

The default value of q = 0.01 corresponds to a conversion of length in cm into weight in grammes. Only if length is in cm and body weight is in grammes the biomass estimates will be given in metric tonnes as shown in SD 3.

The default value for first length to be used in the calculation of mean F is the first length in the observations. Usually, this lower limit has to be raised as the first length groups often cannot be assumed to be under full exploitation.

When you have confirmed that the input is OK the calculations will be carried out and SD 2 appears.

Options 4 and 5 refer to the Thompson and Bell yield forecast program, which is not yet fully developed (thus, these options are not recommended yet).

Selecting the default option results in the tables shown in SD 3

```
--------------------------- SD 1 -----------------------------
!                                                            !
!    - - JONES' LENGTH CONVERTED COHORT ANALYSIS - -         !
!                                                            !
!      Length range    6 - 84                                !
!                                                            !
!  Give L-infinity                          ! 30 !           !
!                                                            !
!  Give K (curvature parameter)             ! .4 !           !
!                                                            !
!  Give M (natural mortality)               ! .5 !           !
!                                                            !
!                 Default terminal F/Z   0.5                 !
!  Give terminal F/Z (exploit. rate)       ! .6 !           !
!                                                            !
!              Default q in W = q L^b    0.01                !
!  Give q in W = q L^b                     !RETURN!           !
!                                                            !
!              Default b in W = q L^b    3                   !
!  Give b in W = q L^b                     !RETURN!           !
!                                                            !
!     Default first length for mean F    6                   !
!  Give first length for mean F            ! 18 !           !
!                                                            !
!  Is input ok ? (y/n) default = y  !RETURN!                 !
!                                                            !
--------------------------- SD 1 -----------------------------
```

Notice that the mean F (weighted by stock number) for lengths > 18 is 0.87, which implies a mean Z of
0.87 + 0.5 = 1.37.
This Z-value can be compared to the Z-value estimated by the length converted catch curve analysis.

In SD 8 in the manual for CCURVE a Z-value of 1.32 was found. If the two values deviate greatly this indicates that the M-value used in the cohort analysis is inappropriate.

```
--------------------------- SD 2 -----------------------------
!                                                            !
!       -- JONES' LENGTH CONVERTED COHORT ANALYSIS --        !
!                                                            !
!        1 : Print results on screen                         !
!        2 : Print results on printer                        !
!        3 : Redo analysis with same input data              !
!        4 : Save results for Thompson and Bell analysis     !
!        5 : Run Thompson and Bell analysis                  !
!        6 : Quit (return to main menu)                      !
!                                                            !
!           Choose option  (default = 1) !RETURN!            !
!                                                            !
--------------------------- SD 2 -----------------------------
```

SD 3

Interval	C	X*)	N	F/Z	F	Z
6.00- 7.00	7.000	1.0270	50239.48	0.0027	0.0013	0.5013
7.00- 8.00	91.000	1.0282	47629.79	0.0342	0.0177	0.5177
8.00- 9.00	355.000	1.0295	44966.94	0.1230	0.0702	0.5702
9.00- 10.00	551.000	1.0310	42081.85	0.1822	0.1114	0.6114
10.00- 11.00	758.000	1.0326	39057.62	0.2399	0.1578	0.6578
11.00- 12.00	1113.000	1.0344	35897.89	0.3253	0.2410	0.7410
12.00- 13.00	1473.000	1.0364	32475.91	0.4024	0.3367	0.8367
13.00- 14.00	1856.000	1.0386	28815.22	0.4771	0.4563	0.9563
14.00- 15.00	2077.000	1.0412	24925.28	0.5289	0.5614	1.0614
15.00- 16.00	2106.000	1.0441	20998.56	0.5613	0.6397	1.1397
16.00- 17.00	2010.000	1.0474	17246.39	0.5835	0.7004	1.2004
17.00- 18.00	1852.000	1.0513	13801.51	0.6021	0.7567	1.2567
18.00- 19.00	1653.000	1.0559	10725.83	0.6189	0.8120	1.3120
19.00- 20.00	1417.000	1.0614	8054.94	0.6327	0.8611	1.3611
20.00- 21.00	1158.000	1.0681	5815.20	0.6427	0.8994	1.3994
21.00- 22.00	899.000	1.0764	4013.42	0.6493	0.9256	1.4256
22.00- 23.00	660.000	1.0870	2628.77	0.6526	0.9395	1.4395
23.00- 24.00	452.000	1.1011	1617.50	0.6513	0.9340	1.4340
24.00- 25.00	284.000	1.1207	923.53	0.6431	0.9009	1.4009
25.00- 26.00	164.000	1.1497	481.90	0.6309	0.8546	1.3546
26.00- 27.00	84.000	1.1970	221.95	0.6122	0.7892	1.2892
27.00- 28.00	40.000	1.2884	84.74	0.6179	0.8085	1.3085
28.00 plus	12.000	0.0000	20.00	0.6000	0.7500	1.2500
	Total		432724.21			

*) X = ((L8-L(i))/(L8-L(i+1)))^(M/2K)

Interval	W grammes	N*W tons	C*W tons
6.00- 7.00	2.7950	0.1404	0.0000
7.00- 8.00	4.2750	0.2036	0.0004
8.00- 9.00	6.2050	0.2790	0.0022
9.00- 10.00	8.6450	0.3638	0.0048
10.00- 11.00	11.6550	0.4552	0.0088
11.00- 12.00	15.2950	0.5491	0.0170
12.00- 13.00	19.6250	0.6373	0.0289
13.00- 14.00	24.7050	0.7119	0.0459
14.00- 15.00	30.5950	0.7626	0.0635
15.00- 16.00	37.3550	0.7844	0.0787
16.00- 17.00	45.0450	0.7769	0.0905
17.00- 18.00	53.7250	0.7415	0.0995
18.00- 19.00	63.4550	0.6806	0.1049
19.00- 20.00	74.2950	0.5984	0.1053
20.00- 21.00	86.3050	0.5019	0.0999
21.00- 22.00	99.5450	0.3995	0.0895
22.00- 23.00	114.0750	0.2999	0.0753
23.00- 24.00	129.9550	0.2102	0.0587
24.00- 25.00	147.2450	0.1360	0.0418
25.00- 26.00	166.0050	0.0800	0.0272
26.00- 27.00	186.2950	0.0413	0.0156
27.00- 28.00	208.1750	0.0176	0.0083
28.00 plus	231.4913	0.0046	0.0028
	Total	9.3758	1.0697

Mean F (L >= 18) : .8694 (weighted by stock number)

The estimates of biomass in SD 3 (N*W tonnes) and yield (C*W tonnes) assume the weight length relationship to be given in units of grammes and centimeters.

SD 3 is followed by SD 4, which gives a summary table of the input parameters.

```
-------------------------- SD 4 --------------------------
!                                                        !
! These results were obtained using the parameters :     !
!                                                        !
!    L8 (L-infinity              30                      !
!    K (curvature parameter)     0.4                     !
!    M (natural mortality)       0.5                     !
!    Terminal exploitation rate  0.6                     !
!    M/2K                        0.625                   !
!    q in W = q L^b              0.01                    !
!    b in W = q L^b              3                       !
!                                                        !
!    !RETURN!                                            !
-------------------------- SD 4 --------------------------
```

The menu shown in SD 2 will appear when you press RETURN in SD 4.

Option 3 in SD 2 provide the option of a new run with different input parameters.
Selecting option 3 produces SD 5 which is similar to SD 1 except for the default values.

The terminal exploitation rate F/Z is often unknown and the value used may simply be a guess.
The SD 5 menu offers a convenient way of altering the input F/Z by using the default values of all other input parameters, (these will then be the same values as used in the preceeding run), and only entering the new value of F/Z.

The usual procedure is to determine the terminal F/Z (by trial and error) so that the last two to four exploitation rates are approximately equal.

Any input parameter may be changed as illustrated in SD 5.

Having confirmed the input values the calculations are executed, and the menu SD 2 appears on the screen.

```
---------------------------- SD 5 -----------------------------
!                                                             !
!     - - JONES' LENGTH CONVERTED COHORT ANALYSIS - -         !
!                                                             !
!     Length range    6 - 84                                  !
!                                                             !
!                Default L-infinity          30               !
!  Give L-infinity                          ! 32 !            !
!                                                             !
!                Default K                   0.4              !
!  Give K (curvature parameter)             !RETURN!          !
!                                                             !
!                Default M                   0.5              !
!  Give M (natural mortality)               ! .6 !            !
!                                                             !
!                Default terminal F/Z        0.6              !
!  Give terminal F/Z (exploit. rate)        ! .7 !            !
!                                                             !
!                Default q in W = q L^b      0.01             !
!  Give q in W = q L^b                      !RETURN!          !
!                                                             !
!                Default b in W = q L^b      3                !
!  Give b in W = q L^b                      !RETURN!          !
!                                                             !
!     Default first length for mean F      18                 !
!  Give first length for mean F            !RETURN!          !
!                                                             !
!  Is input ok ? (y/n) default = y          !RETURN!          !
!                                                             !
---------------------------- SD 5 -----------------------------
```

3.17.4. PRINTER OUTPUT.

The printed output is similar to the screen output shown in SD 3 together with the run identification.

3.17.5. CONNECTION TO OTHER PROGRAMMES.

LCOHOR can produce a disk file of the type :

"RESULTS FROM LENGTH COHORT ANALYSIS"

which can be used as input by the program TBYR (which is not yet available, but under development).

Estimates of Z for the length groups under full exploitation from LCOHOR and from estimates of Z from CCURVE (Length converted catch curve analysis) can be compared for evaluation of the estimate of natural mortality, M (which is usually guessed).

4. AGE/LENGTH DATA (AL) SUB-PACKAGE.

4.1. INTRODUCTION.

Below follows a list of the programs contained in the AL-subpackage together with a very short description of the programs.

Figure 4.1.1 shows the possible flows of data between the programs.

The names of the programs all start by "VB" which stands for "Von Bertalanffy".

All programs in the AL subpackage deals with estimation of von Bertalanffy growth parameters from age/length data.

It is assumed that absolute ages of individual fish are known from e.g. counting of ring structures of hard parts (otoliths or scales).

AL.1. VBMENU : AL main menu.
The menu program by which you load the programs from the program diskette (no manual for this program).

AL.2. VBINPUT : AL data entry program.
This program is used to enter raw data, i.e. series of pairs of age and length (t,L) (e.g. from otolith reading). VBINPUT also offers an option for editing and amending.
The (t,L) pairs can be entered in any order as VBINPUT sorts them in chronological order.
New pairs can be added and existing files can be modified.
VBINPUT offers a number of options for data transformation.
VBINPUT can produce a table of input data on the printer.

AL.3. VBMERGE. AL file merging program.
Merges age/length files.

AL.4. VONBER. Estimation of von Bertalanffy parameters.
This is the main program of the subpackage.
It estimates the von Bertalanffy parameters using non linear regression analysis.
It calculates approximative confidence limits of the estimates.

AL.5. VBRESU. AL table/result program.
Prints the results and the input data of VONBER.

AL.6. VBGRAPH. Graph of estimated von Bertalanffy growth curve.
Produces a graph with the observations and the estimated growth curve.

DIMENSION OF AL-PROGRAMS :

All programs in the AL subpackage are dimensioned to accept a maximum number of 500 pairs of age and length observations.

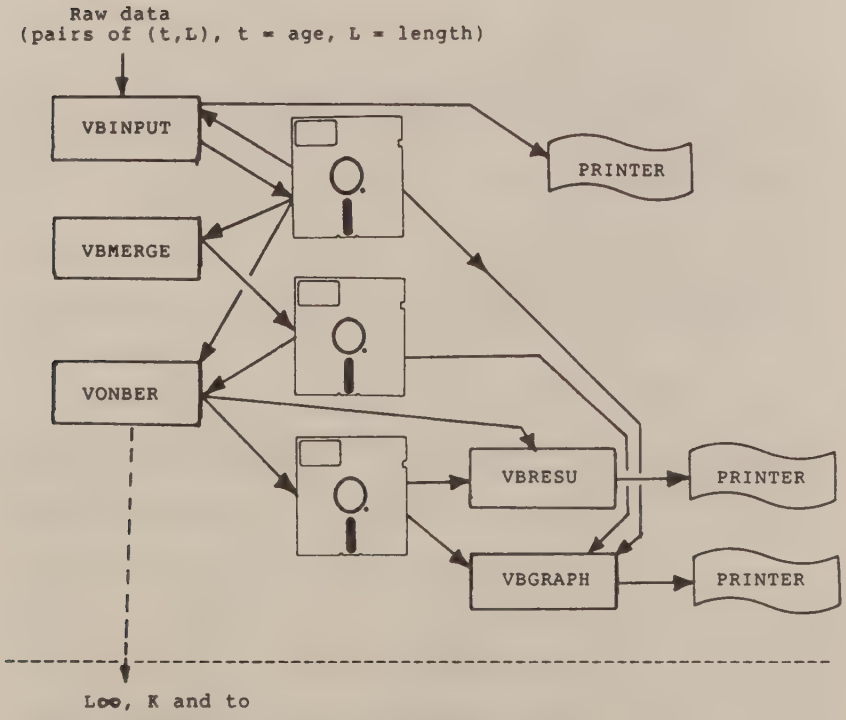


Figure 4.1.1. Data flows in the age/length subpackage

4.2. VBINPUT.

4.2.1. PURPOSE.

The purpose of the program VBINPUT is to create files with age/length data and to store these on diskette for subsequent estimation of the von Bertalanffy growth parameters by means of the program VONBER.

4.2.2. INPUT / INPUT FILE.

VBINPUT can handle input from the screen and can take input from a disk file, which has been created and saved by a previous run of the program.

The files created by VBINPUT (or VBMERGE) are of type:

" AGE LENGTH DATA "

VBINPUT also accepts files of the type
"AGE LENGHT DATA + RESULTS"
i.e. file created by VONBER (But the results will be deleted unless the name of the file is changed).

4.2.3. SCREEN DIALOGUE.

The opening screen display SD 1 asks whether you want to enter data from the screen or from a file on a diskette, and it offers you a help facility.
The text in the "help"-display summarises the possible input formats and is shown in SD 2.

```
------------------------------ SD 1 ----------------------------
!                                                               !
!   - - VON BERTALANFFY GROWTH EQ. DATA INPUT PROGRAM - -       !
!                                                               !
!                If you want help, type 'h'                     !
!                                                               !
! Do you want to enter data from screen or from disk (s/d) !h!! !
!                                                               !
------------------------------ SD 1 ----------------------------
```

The input procedure used by VBINPUT is similar to that used by the program REGRES (linear regression analysis).

If you are not going to work on data which is on a disk file you select the 's' option in SD 1, and you are ready to input data from the screen in SD 3.

```
---------------------------- SD 2 ----------------------------
!                                                            !
! This program estimates the von Bertalanffy parameters L8, K !
! and to.                                                    !
!          L(i) = L8*(1 - exp(-K*(t(i)-to)) ) , i = 1,2,...,n !
!          from the observations  (L(i),t(i)) , i = 1,2,...,n !
!          t(i) = age,  L(i) = length at age t(i)            !
!                                                            !
! The input data formats are :                               !
!                                                            !
! Option 1: t(i)/L(i) (one single pair of observations). Notice !
!           that the symbol '/' is used to separate t and L  !
!                                                            !
! Option 2: t(i)/L(i)*n(i)  (n(i) pairs of equal observations) !
!           This option may be used for weighting the obser- !
!           vations. Thus, n(i) need not to be an integer.   !
!                                                            !
! Option 3: t(i)/L(i)+L(i+1)+...+L(i+m)  (several pairs of ob- !
!           ervations all with the same t). The program assigns !
!           appropriate values to the t-index. I.e. entering !
!           each pair at a time would be equivalent.         !
!                                                            !
! Option 4: t(i)/L(i)*n(i)+L(i+1)*n(i+1)+...+L(i+m)*n(i+m)   !
!           I.e. any combination of options 1, 2 and 3.      !
!                                                            !
! The input data set :                                       !
!   i      1    2    3    4    5    6    7    8    9   10    !
! ------------------------------------------------------     !
! t(i)     2    3    3    4    4    5    5    5    5    5     !
! L(i)   4.5  5.9  5.9  7.0  7.1  7.8  7.8  7.9  8.0  8.0     !
!                                                            !
! can be entered in the following way :                      !
!  2/4.5                                                     !
!  3/5.9*2                                                   !
!  4/7.0+7.1                                                 !
!  5/7.8*2+7.9+8.0*2                                         !
!                                                            !
! but you could also do it the more elaborate way :          !
!  2/4.5                                                     !
!  3/5.9                                                     !
!  3/5.9                                                     !
!  4/7.0                                                     !
!  4/7.1                                                     !
!  ... etc.                                                  !
!                                                            !
! The program sorts the t's in increasing order.             !
! L's with equal t are also sorted in increasing order.      !
!                                                            !
! Whenever you want, you can take a look at the ordered input !
! data set. The program offers you the option to stop the ente- !
! ring of data, have them sorted, and then continue the ente- !
! ring process.                                              !
! At that point of the program execution you will have the op- !
! purtunity to delete incorrect data, and to replace by correct !
! ones.                                                      !
!                                                            !
---------------------------- SD 2 ----------------------------
```

```
---------------------------- SD 3 -------------------------------
!                                                               !
!Print  'e' for sorting and listing or for 'end of data'        !
!                                                  ('h' for help)!
!Obs. no.  (t,L) , (t,L*n) ,(t,L+L+...+L), (t,L*n+L*n+...+L*n) !
!---------------------------------------------------------------!
!    1       ! 1.5/27.5+27.2!                                   !
!    3       ! 0.5/13       !                                   !
!    4       ! 0.2/7        !                                   !
!    5       ! 0.8/18*2     !                                   !
!    6       ! e            !                                   !
!                                                               !
---------------------------- SD 3 -------------------------------
```

In the example in SD 3 several of the possible formats (cf. SD 2) has been used.

The second and third lines contain single points, and the fourth line represent two identical observations, both of value (0.8,18).
The first line represents two points with the same t-value, namely (1.5,27.5) and (1.5,27.2).

It should be noted that the first coloumn counts the number of t-observations entered.
Each line and each plus sign counts one whereas the multiplication sign does not count.

At any stage in the input process you can interrupt and see a listing of the sorted values you have entered.
When 'e' is typed (in the fourth or the last line in SD 3) SD 4 appears.

```
---------------------------- SD 4 -------------------------------
!                                                               !
!   - - VON BERTALANFFY GROWTH EQ. DATA INPUT PROGRAM - -       !
!                                                               !
!  1 : Continue entering data                                   !
!                                                               !
!  2 : Look over/delete input data                              !
!                                                               !
!  3 : Perform parameter estimation       VONBER                !
!                                                               !
!  4 : Transform data                                           !
!                                                               !
!  5 : Save data on diskette                                    !
!                                                               !
!  6 : Print table                                              !
!                                                               !
!  7 : Quit (return to main menu)                               !
!                                                               !
! Choose option                 ! 2 !                          !
!                                                               !
---------------------------- SD 4 -------------------------------
```

Option 2 in SD 4 prints each observation as you successively scroll through the data lines with aid of the RETURN key (see SD 5).

In each line you may terminate the examination by 'e' or you may skip the next 10 observations by 's' (skip 20 by 'ss' etc.).

Notice that the observations have been sorted with increasing t and increasing L for equal t's.

```
------------------------------ SD 5 -------------------------------
!'e':end of examination. 'd':delete(X,Y). 'h':help. 's':skip ten !
!  I (obs.no.)     t(i)         L(i)      Weight of L(i)           !
!-------------------------------------------------------------    !
!                                                                  !
!  1              0.200         7.000         1.000   !RETURN!    !
!  2              0.500        13.000         1.000   !RETURN!    !
!  3              0.800        18.000         2.000   !RETURN!    !
!  4              1.500        27.200         1.000   !RETURN!    !
!  5              1.500        27.500         1.000   !RETURN!    !
!  6                                          End of data         !
------------------------------ SD 5 -------------------------------
```

While using the RETURN to scroll in SD 5 you may delete observations. This is the way to correct a misprint made in SD 3. You delete the misprinted observation in SD 5 and go back to SD 3 (via the menu in SD 4) and reenter the correct figures.

When SD 5 is completed the menu in SD 4 will reappear and you can continue the entering of data (Option 1).This is shown in SD 6.

```
------------------------------ SD 6 -------------------------------
!Print  'e' for sorting and listing or for 'end of data'           !
!                                                    ('h' for help)!
!Obs. no.  (t,L) , (t,L*n) ,(t,L+L+...+L), (t,L*n+L*n+...+L*n)    !
!-------------------------------------------------------------    !
!   6       !  2/32.5*2+32.3*3 !                                   !
!   8       !  2.5/36.4        !                                   !
!   9       !  3/39.3+40       !                                   !
!   11      !  5/46.1*3        !                                   !
!   12      !  e               !                                   !
!                                                                  !
------------------------------ SD 6 -------------------------------
```

When all data has been entered the input process is terminated by 'e'. SD 4 will appear and you can save the data on diskette by choosing option 5.

If you do not save you get a warning of the type shown in SD 7. After the warning SD 4 reappears and you get another chance to save the file on disk.

```
--------------------------- SD 7 -----------------------------
!                                                            !
!     *** WARNING ***    Data not saved on diskette          !
!                                                            !
--------------------------- SD 7 -----------------------------
```

Input data can be displayed on the printer using option 6 in menu SD 4. The printed input data is shown in SD 8.

```
--------------------------- SD 8 -----------------------------
!                                                            !
! Von Bertalanffy growth parameter estimation example        !
!                                                            !
!  I            t(i)          L(i)           N(i)           !
!------------------------------------------------------------!
!  1           0.200          7.000          1.000          !
!  2           0.500         13.000          1.000          !
!  3           0.800         18.000          2.000          !
!  4           1.500         27.200          1.000          !
!  5           1.500         27.500          1.000          !
!  6           2.000         32.300          3.000          !
!  7           2.000         32.500          2.000          !
!  8           2.500         36.400          1.000          !
!  9           3.000         39.300          1.000          !
! 10           3.000         40.000          1.000          !
! 11           5.000         46.100          3.000          !
!                                                            !
! Do you want the input data printed (y/n) default = y       !
!                                                 !RETURN!   !
!                                                            !
--------------------------- SD 8 -----------------------------
```

The parameter estimation can be initiated by choosing option 3 in the menu SD 4 which loads the program VONBER and starts the estimation procedure.
You may either go directly to VONBER via option 3 (SD 4), or you save the file and then initiate the program VONBER in another run.

Option 4 in SD 4 offers you five different data transformations as shown in SD 9.

Option 1 in SD 9 divides all t-values by 365.
Option 3 (the one selected in SD 9) may be used to e.g. convert total length into fork length.
Option 4 in SD 9 can be used to convert weights into lengths.

```
------------------------- SD 9 -----------------------------
!                                                          !
!                   DATA TRANSFORMATION                    !
!                                                          !
!          1 : t : From days to years                      !
!                                                          !
!          2 : t : t-new = A + B * t-old                   !
!                                                          !
!          3 : L : L-new = A + B * L-old                   !
!                                                          !
!          4 : L : L-new = A * L-old^B                     !
!                                                          !
!          5 : N : N-new = A * N-old^B                     !
!                                                          !
!          6 : Quit                                        !
!                                                          !
!          Choose option   ! 3   !                         !
!                                                          !
!          Give A     ! 0.056 !                            !
!          Give B     ! 0.91  !                            !
!                                                          !
!       Is input ok ? (y/n) default = y !RETURN!           !
!                                                          !
------------------------- SD 9 -----------------------------
```

4.2.4. PRINTER OUTPUT.

A table of input data can be displayed on the printer by selecting option 6 in SD 4.
The printed table is identical to that shown in SD 8.

4.2.5. CONNECTION TO OTHER PROGRAMS.

The program VBINPUT is intended for input of age/length data for subsequent estimation of von Bertalanffy growth parameters using the program VONBER.

The type of files created by VBINPUT is

" AGE LENGTH DATA "

Files created by VBINPUT can ALSO be retrieved by the programs

VBMERGE (merging of age length files)
and
VBGRAPH (graph of observations and growth curve)

4.3. VBMERGE.

4.3.1. PURPOSE.

The program VBMERGE can be used to merge two or more files containing age length data into one file.

4.3.2. INPUT / INPUT FILE.

The input files must be of the type:
" AGE LENGTH DATA "
i.e. they are created by the program VBINPUT (or VBMERGE).

Also files of the type " AGE LENGTH DATA + RESULTS " (i.e. output from VONBER) can be retrieved by VBMERGE, but the re-sults will be deleted.

4.3.3. SCREEN DIALOGUE.

After you have chosen the disk drive, SD 1 appears. SD 1 lists the files on the diskette and you are required to give the names of the files to be merged.

The list of file names is terminated by keying RETURN.

```
--------------------------- SD 1 -----------------------------!
!                                                             !
!          - - MERGING OF AGE/LENGTH FILES - -                !
!                                                             !
!        Give disk drive (1/2) default = 2   !RETURN !        !
!                                                             !
!      /DECAPTERUS.83                                         !
!                                                             !
!      NAME              TYPE      BLOCKS     MODIFIED       !
!                                                             !
!       SOFALA.BANK.1    TXT          7       3-DEC-83       !
!       SOFALA.BANK.2    TXT          9       6-JAN-84       !
!       GREAT.BANK.1     TXT         10       9-JAN-84       !
!       GREAT.BANK.2     TXT          8      12-DEC-83       !
!       ..............................                        !
!       ..............................                        !
!                                                             !
!      BLOCKS FREE 52       BLOCKS USED 228                   !
!                                                             !
!       To terminate list of files enter 'return'             !
!                                                             !
!       Give name of file no 1 !SOFALA.BANK.1!                !
!       Give name of file no 2 !SOFALA.BANK.2!                !
!       Give name of file no 3 !   RETURN    !                !
!                                                             !
!--------------------------- SD 1 -----------------------------!
```

In the example of SD 1 only two files are merged, but any number of files could have been merged as long as the maxi-mum number of age/length pairs is not exceeded (the maximum number of pairs is 500, cf. the introduction).

Having chosen the files you get a summary showing the file names, run identifications and the number of age/length pairs (SD 2).

```
------------------------------ SD 2 ----------------------------
!                                                               !
! File           Run identification                             !
!---------------------------------------------------------------!
! SOFALA.BANK.1  Decapterus russellii. Jan. Mar. Sofala Bank !
!                          Number of (t,L) pairs   161          !
!                                                               !
! SOFALA.BANK.2  Decapterus russellii. Apr. Jun. Sofala Bank !
!                          Number of (t,L) pairs   157          !
!                                                               !
!---------------------------------------------------------------!
!                       Total number of (t,L) pairs  318        !
!---------------------------------------------------------------!
!                                                               !
!To start merging press 'return'.To redo selection of files    !
!                                                 enter 'r'     !
!                                                               !
------------------------------ SD 2 ----------------------------
```

The two files are now merged and sorted and the new file can be saved.

4.3.4. PRINTER OUTPUT.

VBMERGE does not produce any printer output.

4.3.5. CONNECTION TO OTHER PROGRAMMES.

VBMERGE produces files which can be used as input for :

- VBINPUT (Age/length data entry program)
- VBMERGE
- VONBER (Estimation of von Bertalanffy growth parameters)
- VBGRAPH (graph of observations and growth curve)

4.4. VONBER.

4.4.1. PURPOSE.

The program VONBER estimates the growth parameters L8, K and to (t-zero) in the ordinary von Bertalanffy (1934) model :

$$L(i) = L8*(1 - \exp(- K*(t(i) - to))) \text{ , } i=1,2,...n.$$

from pairs of observed age and length (t(i),L(i)), i=1,2,...,n

The program uses a non linear least squares procedure, where the estimates L8, K and t-zero are determined to minimize the sum of squared deviations (SSD) between the observations and the estimated growth curve, i.e. so that the sum :

$$SSD = \sum_{i=1}^{n} (L(i) - L8*(1 -\exp(-K*(t(i) - to))))^2$$

is minimized.

The procedure is iterative and requires an initial guess of the parameters (which may be determined by the program or given by the user).

The procedure used is the Newton iteration method. For further details, see Section 4.4.6.

4.4.2. INPUT / INPUT FILE.

The input file must be of the type :

" AGE LENGTH DATA "

or

" AGE LENGTH DATA + RESULTS "

i.e. created by the program VBINPUT or saved from an earlier run with VONBER.
The example used in this manual is the same data as used in the manual for the program VBINPUT.

4.4.3. SCREEN DIALOGUE.

After retrieval of the input file SD 1 shows the run identification and the number of lines of observations.

```
------------------------------ SD 1 -------------------------
!                                                           !
!  Run identification :                                     !
!                                                           !
!  VON BERTALANFFY GROWTH PARAMETER EXAMPLE                 !
!                                                           !
!  Number of observations  11                  !RETURN!     !
!                                                           !
------------------------------ SD 1 -------------------------
```

SD 2 offers (in options 1 and 2) the possibility of checking the input data and excluding some of them from the analysis.

```
------------------------------ SD 2 -------------------------
!                                                           !
!   - - VON BERTALANFFY GROWTH PARAMETER ESTIMATION - -     !
!                                                           !
!   1 : Look over input data                                !
!                                                           !
!   2 : Exclude observations                                !
!                                                           !
!   3 : Perform parameter estimation                        !
!                                                           !
!   4 : Save results on disk                                !
!                                                           !
!   5 : Do another run with VONBER                          !
!                                                           !
!   6 : Print results       VBRESU                          !
!                                                           !
!   7 : Print graph         VBGRAPH                         !
!                                                           !
!   8 : Quit (and return to main menu)                      !
!                                                           !
!   Choose option (default = 3)                             !
!                                                           !
------------------------------ SD 2 -------------------------
```

To start with an inspection of the input option 1 in SD 2 should be selected and SD 3 appears.

The table in SD 3 is the same as the table of input data produced by VBINPUT (SD 8 in the manual for VBINPUT).

```
---------------------------- SD 3 -----------------------------
!                                                             !
!   'e' : end of examination.    's' : skip ten               !
!                                                             !
!I (obs.no.)  t(i)        L(i)          N(i)                  !
!-------------------------------------------------------------!
!                                                             !
!  1          0.200         7.000         1.000   !RETURN!   !
!  2          0.500        13.000         1.000   !RETURN!   !
!  3          0.800        18.000         2.000   !RETURN!   !
!  4          1.500        27.200         1.000   !RETURN!   !
!  5          1.500        27.500         1.000   !RETURN!   !
!  6          2.000        32.300         3.000   !RETURN!   !
!  7          2.000        32.500         2.000   !RETURN!   !
!  8          2.500        36.400         1.000   !RETURN!   !
!  9          3.000        39.300         1.000   !RETURN!   !
! 10          3.000        40.000         1.000   !RETURN!   !
! 11          5.000        46.100         3.000   !RETURN!   !
!                                                             !
!                                        End of data          !
!                                                             !
---------------------------- SD 3 -----------------------------
```

The display SD 3 is scrolled by pressing RETURN. You may skip the next ten observations by keying 's' (the 20 next observations by 'ss', ..., etc.).

Option 2 in the menu SD 2 can be used to exclude observations from the analysis. This is shown in SD 4. The effect of 'd' is that N(i) is assigned the value 0.

```
---------------------------- SD 4 -----------------------------
!                                                             !
!  'e' : end looking over.    'd' : exclude (t,L).            !
!                                                             !
!I (obs.no.)  t(i)        L(i)          N(i)                  !
!-------------------------------------------------------------!
!                                                             !
!  1          0.200         7.000         1.000   !RETURN!   !
!  2          0.500        13.000         1.000   !RETURN!   !
!  3          0.800        18.000         2.000   !RETURN!   !
!  4          1.500        27.200         1.000   !RETURN!   !
!  5          1.500        27.500         1.000   !RETURN!   !
!  6          2.000        32.300         3.000   !   d   !  !
!  7          2.000        32.500         2.000   !RETURN!   !
!  8          2.500        36.400         1.000   !RETURN!   !
!  9          3.000        39.300         1.000   !RETURN!   !
! 10          3.000        40.000         1.000   !RETURN!   !
! 11          5.000        46.100         3.000   !RETURN!   !
!                                                             !
!                                        End of data          !
!                                                             !
---------------------------- SD 4 -----------------------------
```

In this example the observation (2,32.3) was excluded (in the following calculations (2,32.3) has been reentered)

The estimation procedure is started using option 3 in SD 2 which produces SD 5, in which you are requested to give the initial parameter values for the iterative process.
The initial values are needed to start the mathematical algoritm, which finds the minimum of the sum of squares.
The initial parameter values will, as long as they are reasonable, not affect the final estimate.

A default procedure gives a reasonable set of starting values, but you may also select the values on your own.

```
---------------------------- SD 5 -----------------------------
!                                                             !
! Calculate initial guesses of L8, K and to by aid of the     !
!                                        von Bertalanffy plot !
!                                                             !
! Max L = 46.1   Give initial guess of L8    !RETURN!         !
!                                                             !
!                                        -- please wait --    !
!                                                             !
! Von Bertalanffy plot : - log(1-L(t)/L8) = K*to - K*t        !
!                                                             !
!          L8           K            to          SSD         !
! ----------------------------------------------------------- !
! Best choice of initial guess of parameters :                !
!        48.405       0.610         0.111       35.810       !
!                                                             !
! Last choice of initial guess of parameters :                !
!        48.405       0.610         0.111       35.810       !
!                                                             !
! If you want to stop guessing L-values, enter 's' !RETURN!   !
!                                                             !
---------------------------- SD 5 -----------------------------
```

To provide initial guesses of K and t-zero a von Bertalanffy plot is carried out.
To do this a guess of L8 is required, and as is seen in SD 5 the program uses 1.05*Max-L as the default value (46.1*1.05 = 48.05). The parameters shown as the last choice in SD 5 can now be used by the iterative process as starting values.

Answering 's' to the last question in SD 5 starts the iterations.

As an example, another guess of L8 is tested (SD 6).
RETURN in SD 5 gives SD 6 where a new L8 value (e.g. L8 = 49) can be entered.

```
---------------------------- SD 6 -------------------------------
!                                                                !
! Calculate initial guesses on L8, K and to using the           !
!                                        von  Bertalanffy plot ! 
!                                                                !
! Max L = 46.1   Give initial guess of L8    ! 49   !           !
!                                                                !
!                                          -- please wait --    !
!                                                                !
! Von Bertalanffy plot :   - log(1-L(t)/L8) = K*to - K*t         !
!                                                                !
!          L8           K            to          SSD            !
! ------------------------------------------------------------ !
! Best choice of initial guess of parameters :                   !
!        49.000       0.562         0.027       11.418          !
!                                                                !
! Last choice of initial guess on parameters :                   !
!        49.000       0.562         0.027       11.418          !
!                                                                !
! If you want to stop guessing L-values, enter 's' ! s  !       !
!                                                                !
---------------------------- SD 6 -------------------------------
```

The new L8 value gave a sum of squared deviation (SSD) equal to 11.418. This is a lower value than the one found in SD 5, and thus preferable to the value in SD 5. Therefore values for the "best choice" and the "last choice" are identical in SD 6.

You may guess L8 as many times as you like until you terminate by 's', and the program then starts the iterative process.

It is difficult to predict how many iterations are required. If the data conforms nicely to the von Bertalanffy model and the initial guess is a reasonable one only 3 - 5 iterations are required.
But if the data fit better to a straight line than to the curved von Bertalanffy model the iterative process may continue for a long while. You may in many cases save computer time by seaching for a good starting value.

The estimates in each step of the iteration are displayed as shown in SD 7.

If the estimated parameters in the last steps (SD 7) turn out to be outside a realistic range it is time to stop VONBER using "CONTROL C". Only if the data shows the correct "von Bertalanffy trend" will VONBER come out with a result. Thus, you may consider the iterative procedure as a kind of test for von Bertalanffy growth.

The maximum number of iterations VONBER performs is 25. If no parameters are found after 25 iterations it is likely that the data are not "von Bertalanffy data", and VONBER stops.

```
--------------------------- SD 7 ---------------------------
!                                                          !
! Initial guess of growth parameters :                     !
!                                                          !
! L8 = 49.000  K = 0.562   to = 0.027   SSD = 11.418       !
!                                                          !
! ITERATIVE PROCESS PROGRESSION                            !
!                                                          !
! Iter. no.     SSD        L8          K          to       !
!-----------------------------------------------------     !
!    1        1.3940     50.0376     0.4949     -0.0871    !
!    2        0.5732     50.2227     0.4938     -0.1013    !
!    3        0.5732     50.2224     0.4938     -0.1014    !
! End of iteration                                         !
!                                                          !
--------------------------- SD 7 ---------------------------
```

The iterative procedure stops when two consecutive iterations give (nearly) the same result (compare iterations 2 and 3 in SD 7).

The results of the parameter estimation together with the estimated approximate standard deviations and confidence intervals are shown in SD 8.

```
--------------------------- SD 8 ---------------------------
!                                                          !
!  Param.   Estimate    std. dev.   confidence limits      !
! ---------------------------------------------------      !
!   L8      50.22246    0.30565    49.51640   50.92853     !
!   K        0.49388    0.00847     0.47431    0.51344     !
!   to      -0.10139    0.01199    -0.12910   -0.07368     !
!                                                          !
! Number of observations 11                                !
!                                                          !
! Variance covariance matrix                               !
! (upper triangle : corr. coeff.)                          !
!                                                          !
!          L8          K         to                      !
!  ---------------------------------                       !
!   L8    0.09342   -0.90661  -0.52234                     !
!   K    -0.00235    0.00007   0.76747                     !
!   to   -0.00192    0.00007   0.00014                     !
!                                                          !
! Residual variance  0.071649  Res. std. dev.  0.267673    !
!                                                          !
--------------------------- SD 8 ---------------------------
```

In addition SD 8 gives the approximate variance/covariance matrix and the residual standard deviation, s (see Section 6).

You will (nearly) always find that the parameters are strongly correlated. As an example L8 and K have a correlation coefficient of -0.90660 in SD 8.
This means that if K (by chance) is overestimated, then L8 will be underestimated.
As a consequence of this negative correlation the confidence intervals for both K and L8 given in SD 8 are somewhat misleading, because they indicate a very high precision of the estimates of K and L8.

4.4.4. PRINTER OUTPUT.

VONBER does not produce output on the printer. However, the menu SD 2 gives options for loading of programs which will give tables and graphs of results (VBRESU and VBGRAPH respectively).

4.4.5. CONNECTIONS TO OTHER PROGRAMMES.

VONBER can save the results on diskette. The files are of the type :

" AGE LENGTH DATA + RESULTS "

These files can be read by all other programs in the AL subpackage.

4.4.6. THEORY.

The knowledge of this section is not really necessary for running VONBER.

If you are not familiar with theoretical statistics you should skip Section 6 now.

To explain the estimation procedure, let :

Lo = (Lo(1),Lo(2),...,Lo(n)) = vector of observed lengths.

t = (t(1),t(2),...,t(n)) = vector of observed ages.

P(j) = (L8(j),K(j),to(j)) = parameter vector in j'th iteration

L = (L(j,1),L(j,2),...,L(j,n)) = vector of predicted lengths in the j'th iteration.

where $L(j,i) = L8(j)*(1 - \exp(-K(j)*(t(i)-to(j))))$
$i = 1,2,...,n.$

D is the (nX3)-matrix of partial derivatives :

$$D(j) = \begin{Bmatrix} \partial L(j,1)/\partial L8(j) & \partial L(j,1)/\partial K(j) & \partial L(j,1)/\partial to(j) \\ \partial L(j,2)/\partial L8(j) & \partial L(j,2)/\partial K(j) & \partial L(j,2)/\partial to(j) \\ \vdots & \vdots & \vdots \\ \partial L(j,n)/\partial L8(j) & \partial L(j,n)/\partial K(j) & \partial L(j,n)/\partial to(j) \end{Bmatrix}$$

The iterative process is :

$$P(j+1) = P(j) + (D(j)'*D(j))^{-1}*D(j)'*(Lo - L(j))$$

In addition the algorithm searches for the optimum point in the "Newton direction".

The iteration is stopped when two consecutive iterations gave (nearly) the same results.

The variance/covariance matrix is approximated by :

$$V = s^2 (D'*D)^{-1}$$

where s^2 is the residual variance :

$$s^2 = SSD/(N-3) \qquad \text{where} \qquad N = \sum_{i=1}^{n} N(i)$$

The confidence interval of a parameter, p(j), is approximated by

$$p(j) + t(N-3)*\sqrt{v(j,j)}$$

where v(j,j) is the element from the diagonal in V and t(x) is the students statistics with x degrees of freedom.

4.5. VBRESU.

4.5.1. PURPOSE.

The purpose of VBRESU is to print the results of the estimation of von Bertalanffy parameters from the program VONBER. As VBRESU can be accessed directly fron VONBER it may be considered a part of VONBER.

4.5.2. INPUT / INPUT FILE.

The program only accepts input, which has been created by the program VONBER, i.e. files of type:

" AGE LENGTH DATA + RESULTS "

The example used here is the same as the one used in the manual for VONBER.

4.5.3. SCREEN DIALOGUE.

The screen dialogue only deals with retrieval of the input file. The results are shown on the screen before they are printed.

4.5.4. PRINTER OUTPUT.

Table 4.5.4.1. shows the output table. The upper part is identical to SD 8 in the manual for VONBER.
The lower part of Table 4.5.4.1 shows the input data together with the lengths predicted by the estimated growth curve, e.g. :

12.9055 = 50.22247*(1 - exp(-0.49388*(0.5 + 0.10139)))

4.5.5. CONNECTION TO OTHER PROGRAMMES.

VBRESU does not produce any files for use by other programs.

Param.	Estimate	std.dev	confidence limits	
L8	50.22247	0.23104	49.72571	50.71922
K	0.49388	0.00640	0.48011	0.50764
to	-0.10139	0.00906	-0.12088	-0.08189

Number of observations 11

Variance covariance matrix (upper triangle : corr. coeff.)

	L8	K	to
L8	0.05338	-0.90661	-0.52234
K	-0.00135	0.00004	0.76747
to	-0.00110	0.00004	0.00008

Residual variance .0409421441 Res. std. dev. .202341652

Observed age	Observed length	Number of observations	Calculated length	Deviation (Obs.-calc.)
0.2000	7.0000	1.0000	6.9459	0.0540
0.5000	13.0000	1.0000	12.9055	0.0944
0.8000	18.0000	2.0000	18.0445	-0.0445
1.5000	27.2000	1.0000	27.4497	-0.2497
1.5000	27.5000	1.0000	27.4497	0.0502
2.0000	32.3000	3.0000	32.4327	-0.1327
2.0000	32.5000	2.0000	32.4327	0.0672
2.5000	36.4000	1.0000	36.3253	0.0746
3.0000	39.3000	1.0000	39.3662	-0.0662
3.0000	40.0000	1.0000	39.3662	0.6337
5.0000	46.1000	3.0000	46.1795	-0.0795

Table 4.5.4.1. Output table from VBRESU (compare SD 3 and SD 8 in the manual for VONBER).

4.6. VBGRAPH.

4.6.1. PURPOSE.

The purpose of the program VBGRAPH is to produce the graph corresponding to a run of the program VONBER (estimation of von Bertalanffy parameters from age/length data), i.e. to plot length on age together with the estimated growth curve. VBGRAPH may also be used to produce the plot of observations without the growth curve.

4.6.2. INPUT / INPUT FILE.

Input to VBGRAPH must be either a file created by VONBER i.e. of the type:

" AGE LENGTH DATA + RESULTS "

or a file created by VBINPUT, i.e. of the type

" AGE LENGTH DATA "

The example used in the manuals for VBINPUT, VONBER and VBRESU is also used to illustrate VBGRAPH.

4.6.3. SCREEN DIALOGUE.

In SD 1 you are asked to specify the dimensions of the graph. The default graph size is the screen size, i.e. a graph of 21 lines each of 76 characters.

If you wish you may get a larger graph. The maximum size of graph is 100 lines each of 140 characters (on two separate sheets of paper).

You specify a larger graphs by giving the L-interval size and the t-interval size on the axis (see SD 1).

The maximum size graph is obtained by option 'm'

The graph is shown on the screen before it is printed.

SD 2 shows a screen size graph (the one corresponding to the example used in the manuals for VONBER and VBRESU).

Figure 4.6.4.1. shows a maximum size graph with the same data. The circles around the points have been added manually.

```
---------------------------- SD 1 -----------------------------
!                                                             !
!        - - VON BERTALANFFY GROWTH MODEL GRAPH - -           !
!                                                             !
! VON BERTALANFFY GROWTH PARAMETER EXAMPLE                    !
!                                                             !
! Number of (t,L) pairs  11                                   !
!                                                             !
! Min t          Max t          Min L          Max L         !
! ---------------------------------------------------         !
!  0.2            5.0            7.0            46.1         !
!                                                             !
! 'Return' makes the graph becomes 'screen-size'              !
!                                                             !
! 'm' makes the graph becomes 'maximum-size'                  !
!                                                             !
! Give t interval step    !RETURN!                            !
!                                                             !
! Give L interval step    !RETURN!                            !
!                                                             !
! Size of graph : (number of t's X number of L's)=( 74 X 21)  !
!                                                             !
! L8 = 50.22    K = 0.493   to = - 0.102                      !
!                                                             !
! Do you want the curve superimposed (y/n) Default = y !RETURN!!
!                                                             !
! Is input OK ? (y/n) default = y  !RETURN!                   !
!                                                             !
---------------------------- SD 1 -----------------------------
```

The symbols used on the graphs (see SD 2 and Table 4.1 in the manual for VBRESU) mean :

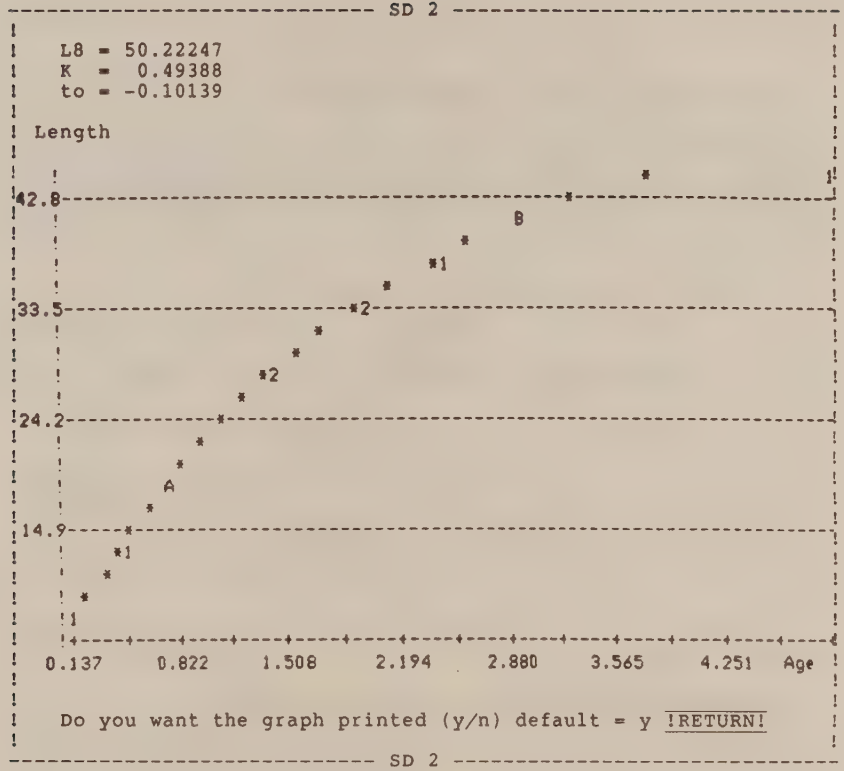
1 : One observation (one line in the input table)
2 : Two observations (two lines in the input table)
    .....
    .....

9 : Nine observations (nine lines in the input table)
0 : More than nine observations (more than nine lines in the input table)

* : Point on the regression line, where there are no observations.

A : One observation on the regerssion line.
B : Two observations on the regerssion line.
    .....
    .....

M : More than nine observations on the regression line.



4.6.4. PRINTER OUTPUT.

The screen size graph shown in SD 2 and the maximum size of graph shown in Figure 4.6.4.1 are examples of printer output. The graph in Figure 4.6.4.1 was printed on two sheets of paper which were subsequently joined and reduced in size.

4.6.5. CONNECTION TO OTHER PROGRAMS.

VBGRAPH does not produce input files for other programs.

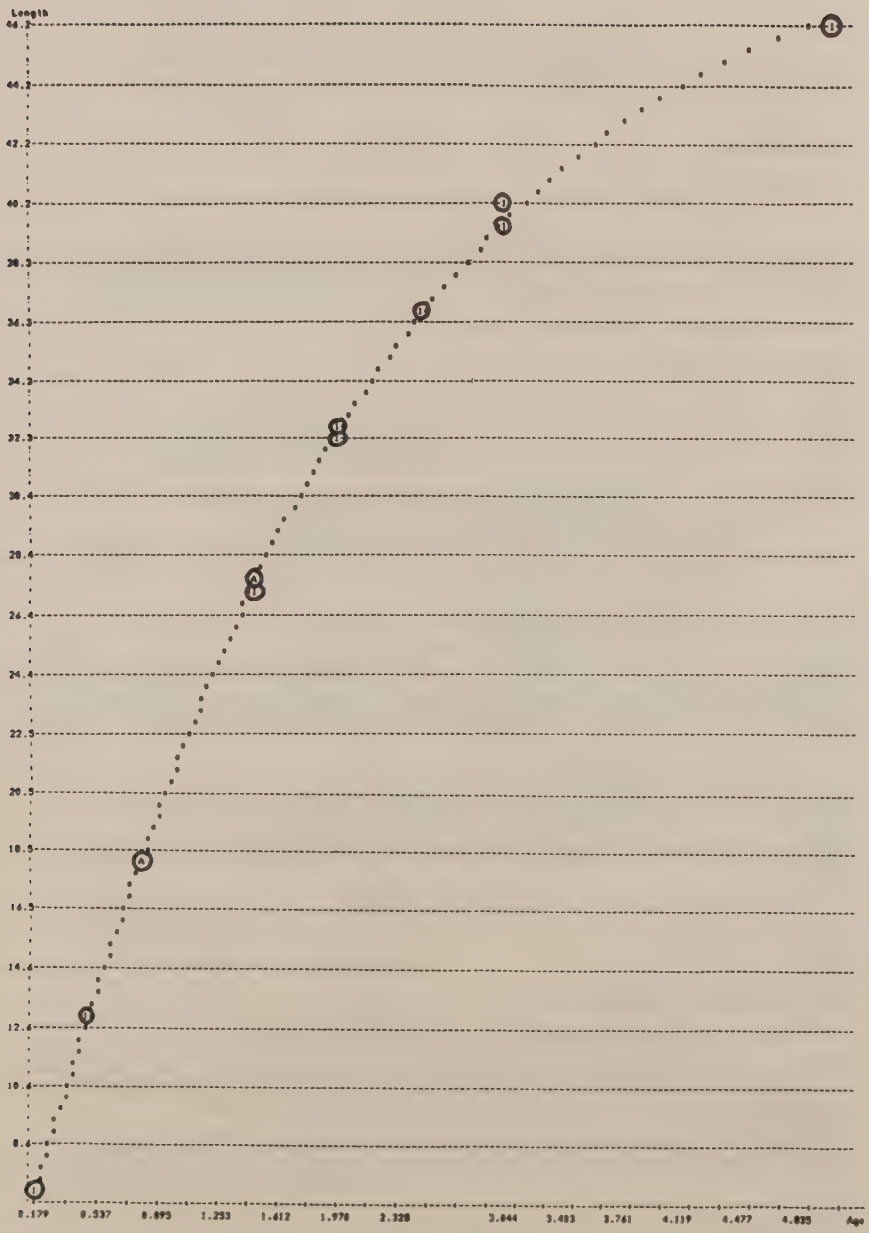


Figure 4.6.4.1. Maximum size graph produced by VBGRAPH.

5. PROGRAMS USING PARAMETERS AS INPUT (PA).

5.1. BHYR.

1. PURPOSE.

To calculate Beverton and Holt (1957) yield per recruit (Y/R) and biomass per recruit (B/R) as a function of fishing mortality in the form suggested by Gulland (1969).

This version of the model reads :

$$Y/R = F * (B/R)$$

$$B/R = \exp(-M(tc-tr)) * W8 * \left(\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K} \right)$$

where :
- $S = \exp(-K(tc-to))$
- K = von Bertalanffy (curvature) parameter
- to = von Bertalanffy (t-zero) parameter
- W8 = von Bertalanffy (asymptotic body weight) parameter
- tc = age at first capture
- tr = age at recruitment
- F = fishing mortality
- M = natural mortality
- $Z = F + M$, total mortality

This model assumes the length weight relationship to be of the form :

$$W = Q * L^3$$

where W is the body weight, L the body length and Q the condition factor.
This is an implication of the von Bertalanffy growth model assumed :

$$W(t) = W8*(1 - \exp(-K*(t-to)))^3$$

where t is the age.

5.1.2. INPUT / INPUT FILE.

BHYR accepts input only from the screen as explained in the next Section. As the number of input figures for the yield/recruit analysis is only five it is not considered worthwhile to save them on disk.

5.1.3. SCREEN DIALOGUE.

BHYR starts with SD 1.

```
---------------------------- SD 1 -------------------------------
!                                                                !
!     - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -        !
!                                                                !
! Give run identification (max 255 characters)                   !
!                                                                !
! ! A hypothetical fish !                                        !
---------------------------- SD 1 -------------------------------
```

SD 2 offers an option which will be discussed later in connection with SD 10.

```
---------------------------- SD 2 -------------------------------
!                                                                !
!     - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -        !
!                                                                !
! Do you want to use the Length/Weight parameters               !
!                                   (y/n) default = n !RETURN!   !
!                                                                !
---------------------------- SD 2 -------------------------------
```

In SD 3 the parameters of the Beverton and Holt model are entered.
The first time you calculate Y/R and B/R the default values are all 0 (except for t-zero). As will appear in SD 9 you can do the calculations as many times as you like. After the first time the default values are those of the previous calculation.

```
---------------------------- SD 3 -------------------------------
!                                                                !
!     - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -        !
!                                                                !
!    Give parameters                                             !
!                                                                !
!    W8  default =    0 !100001                                  !
!    K   default =    0 !0.3  !                                  !
!    to  default = -0.1 !-0.2 !                                  !
!    M   default =    0 !0.3  !                                  !
!    tr  default =    0 !0.1  !                                  !
!    tc  default =    0 !0.5  !                                  !
!                                                                !
!   Is input ok ? (y/n) default = y  !RETURN!                    !
!                                                                !
---------------------------- SD 3 -------------------------------
```

SD 4 asks for the number of F-values in the output table (SD 5). The maximum number of F-values is 100. The program checks that this limit is not exceeded.

```
---------------------------- SD 4 -------------------------------
!                                                               !
!     - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -       !
!                                                               !
!   Give table format :                                         !
!                                                               !
!    Maximum F  default =    3    ! 2   !                      !
!                                                               !
!    F step size default = 0.2    ! 0.1 !                      !
!                                                               !
!   Is input ok ? (y/n) default = y  !RETURN!                   !
!                                                               !
---------------------------- SD 4 -------------------------------
```

SD 5 presents the results of the calculation in table form.

Besides the Y/R and B/R values for each F-value BHYR also calculates the F-value (Fmax) producing the maximum Y/R-value (MY/R).

The symbol F0.1 stands for the value of F which produces a slope of the tangent to the Y/R curve which is one tenth of the slope at the origin, i.e.

$$\left(\frac{d\ (Y/R)}{dF}\right)_{F=F0.1} = 0.1\left(\frac{d(Y/R)}{dF}\right)_{F=0}$$

In some cases the curve has no maximum (this may happen e.g. for large M-values). In this case the line giving Fmax and MY/R will be replaced by :

"The curve has no maximum"

SD 6 offers you a graphical presentation of the results. If the offer is accepted SD 7 follows.

SD 7 offers you two alternative graph sizes. The small graph fits the screen and the large one uses 50 lines each of 140 characters.
The large graph is available only on the printer. An example of a maximum sized graph is shown in Section 4.

The screen size graph is shown in SD 8. Notice that B/R and Y/R are in different scales.

As appears from SD 8 you may also print the graph.

SD 5

A hypothetical fish

W8	10000
K	0.3
to	-0.2
M	0.3
tc	0.5
tr	0.1

F	Y/R	B/R
0.000	0.000	9106.381
0.100	521.085	5210.852
0.200	659.571	3297.856
0.300	671.243	2237.478
0.400	639.330	1598.325
0.500	594.165	1188.330
0.600	547.370	912.284
0.700	503.332	719.046
0.800	463.491	579.364
0.900	428.071	475.635
1.000	396.812	396.812
1.100	369.284	335.712
1.200	345.026	287.521
1.300	323.604	248.926
1.400	304.629	217.592
1.500	287.766	191.844
1.600	272.724	170.452
1.700	259.257	152.504
1.800	247.157	137.309
1.900	236.245	124.340
2.000	226.373	113.186

Fmax = 0.26359 MY/R : 674.69

F0.1 = 0.17199 Y/R for F = F0.1 : 639.59

Do you want the results printed (y/n) default = n !RETURN!

SD 5

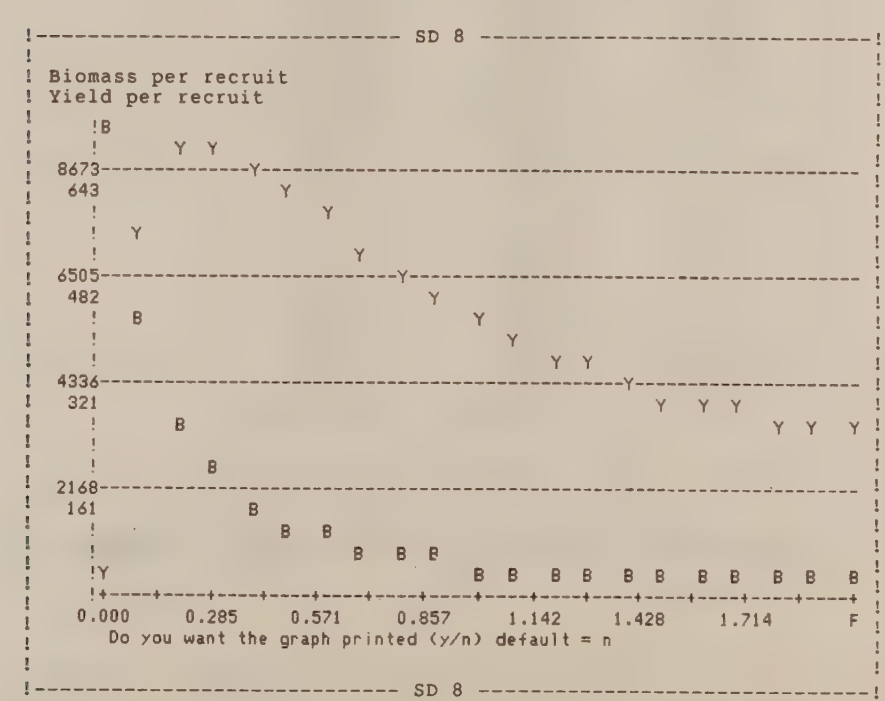
SD 6

- - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -

Do you want the graph (y/n), default = n ! y !

SD 6

```
---------------------------- SD 7 -------------------------------
!                                                               !
!     - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -       !
!                                                               !
!                       - - G R A P H - -                       !
!                                                               !
!     1 : Screen size graph                                     !
!                                                               !
!     2 : Maximum size (140X50). Only for printer               !
!                                                               !
!     Choose option, defualt = 1 !RETURN!                       !
!                                                               !
---------------------------- SD 7 -------------------------------
```



SD 9 offers you the option to redo the calculations with alternative parameter values. If you answer "y" you will go back to SD 2 and SD 3 will now have the parameter values you just used as the default values.

```
---------------------------- SD 9 -------------------------------
!      - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -       !
!                                                                !
!       Do you want to try again (y/n), default = y              !
---------------------------- SD 9 -------------------------------
```

If you answer "y" in SD 2 the parameter input dialogue will be extended. An example of such an extended dialogue is shown in SD 10.

You may for example convert Lc (length at first capture) into a tc-value by choosing this option. The program will in all cases change the parameter values so that they are internally consistent. The valid parameter value is always the last displayed one.

```
---------------------------- SD 10 ------------------------------
!                                                                !
!      - - BEVERTON AND HOLT'S YIELD PER RECRUIT MODEL - -       !
!                                                                !
!     Give parameters  (some are optional)                       !
!                                                                !
!                                        L8 is optional          !
!     L8  default =    0  !RETURN!                               !
!                                        Q in : W = Q*L^d is optional !
!     Q   default =    0  ! 0.01!                                !
!                                        d in : W = Q*L^d is optional !
!                                   (assumed to be 3 in the BH model)!
!     d   default =    3  !RETURN!                               !
!                                                                !
!     W8  default =    0  !10000!                                !
!                                        Calculated L8 = 100     !
!     K   default =    0  !0.3  !                                !
!     to  default = -0.1  !-0.2 !                                !
!     M   default =    0  !0.3  !                                !
!     tr  default =    0  !0.1  !                                !
!                                        Lc is optional          !
!     Lc  default =    0  !RETURN!                               !
!                                        Calculated tc = 0.1     !
!     tc  default =  0.1  !0.5  !                                !
!                                        Calculated Lc = 18.94   !
!                                                                !
!    Is input ok ? (y/n) default = y  !RETURN!                   !
!                                                                !
!---------------------------- SD 10 ------------------------------!
```

5.1.4. PRINTER OUTPUT.

BHYR can produce a table as shown in SD 5 and a graph as shown in SD 8. In addition to this you can get a maximum size graph on two sheets of paper. Figure 5.1.4.1. shows such a large graph where the two sheets have been fitted.

5.1.5. CONNECTIONS TO OTHER PROGRAMS.

BHYR has no connections to other programs.

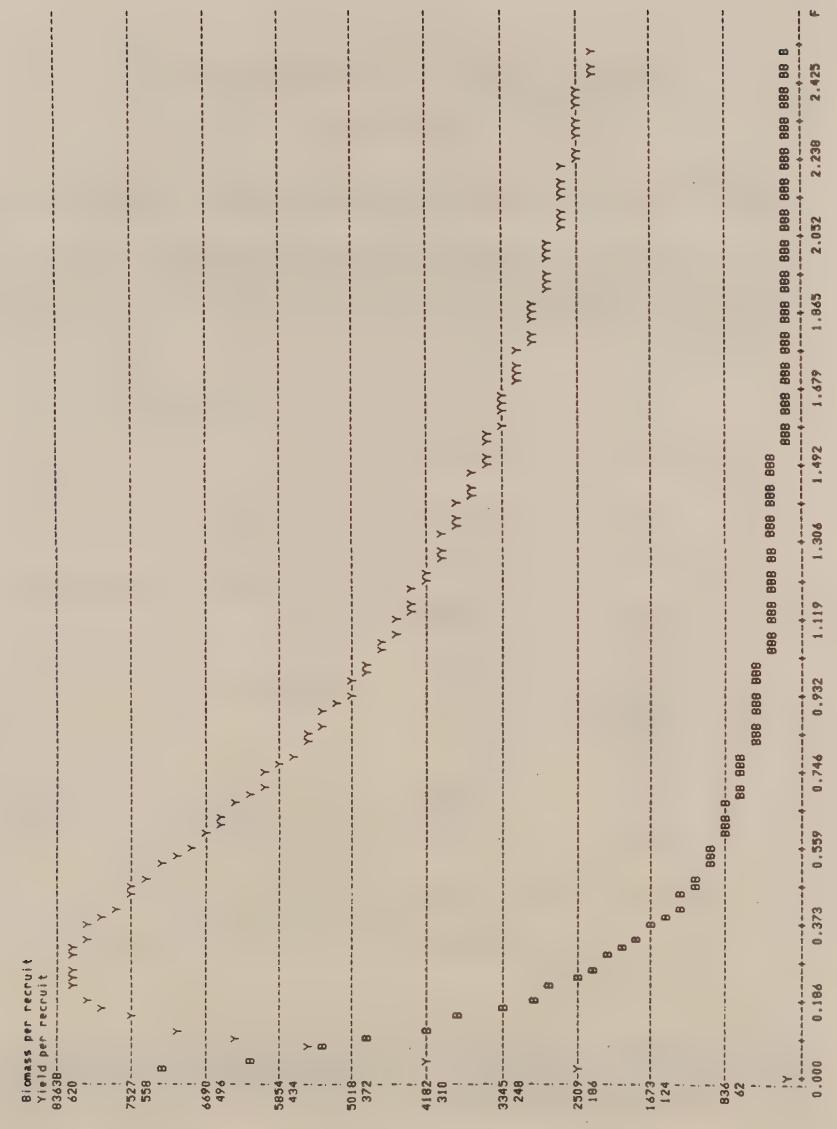


Figure 4.1. Example of large graph. (W8 = 9000, K = 0.3, to = - .2, M = 0.3, tc = 0.5 and tr = 0.1)

6. GENERAL PURPOSE PROGRAMS (GEN).

6.1. REGRES.

6.1.1. PURPOSE.

The purpose of the program REGRES is to perform ordinary least squares linear regression analysis.
The regression analysis fits a straight line to a set of pairwise observations, usually denoted 'X' and 'Y'.
Linear regression analysis has wide application in fish stock assessment.

The model is :

$$Y(i) = a + b * X(i)$$

where i = 1,2,...,n is the index of observation. Y(i) is the dependent observation i and X(i) is independent observation i. The parameters to be estimated are a, the intercept, and b, the slope. REGRES also estimates confidence limits of the estimates.

In the program REGRES the usual regression analysis has been combined with various options for data transformation. The transformation part of the program used in combination with the regression part of the program enables some selected non-linear curves to be fitted with the program REGRES.

REGRES is also used to enter data from screen, to retrieve files from diskettes and to save data. Thus, there is no separate data entry program for REGRES.

6.1.2. INPUT / INPUT FILE.

REGRES can take input from the screen, and it can take input from a file, which has been created and saved by a previous run of the program.

The files created by REGRES are of type:

" ORDINARY LINEAR REGRESSION "

6.1.3. SCREEN DIALOGUE.

The opening screen display SD 1 asks whether you want to enter data from the screen or from a disk file, and it offers you a help option. The text in the "help"-display is shown in SD 2. It summarises the possible input formats and the syntax for the data entering and editing

```
------------------------------ SD 1 ----------------------------
!                                                               !
!        - - ORDINARY LINEAR REGRESSION ANALYSIS - -            !
!                                                               !
!               If you want help, type 'h'                      !
!                                                               !
! Do you want to enter data from screen or from disk (s/d) !h!  !
!                                                               !
------------------------------ SD 1 ----------------------------
```

The input procedure used here is similar to the one used by the program VBINPUT (data entry program for estimation of von Bertalanffy parameters from age/length data).

If your data are not already in a file you select the 's' option in SD 1, and you are ready to enter data from the screen as illustrated in SD 3.

```
------------------------------ SD 3 ----------------------------
!                                                               !
!Print  'e' for sorting and listing or for 'end of data'        !
!                                                ('h' for help) !
!Obs. no.  (X,Y) , (X,Y*N) ,(X,Y+Y...+Y), (X,Y*N+Y*N+...+Y*N)  !
!-------------------------------------------------------------- !
!   1       !  13.0/3.5*2   !                                   !
!   2       !  11.2/3       !                                   !
!   3       !  12.4/3.2+3.3 !                                   !
!   5       !  e            !                                   !
!                                                               !
------------------------------ SD 3 ----------------------------
```

In the example in SD 3 several of the possible data formats have been used. The second line is a single point, and the third line represents two points with the same X-value,namely (12.4,3.2) and (12.4,3.3). The first line represents two identical observations, both of value (13.0,3.5).

It should be noted that the first column counts the number of individual X-observations. A line or a plus sign counts for one X-value, whereas the multiplication sign does not count.

At any stage in the input process you can interrupt if you want to see a listing of the data you have entered. You interrupt using 'e' which produces SD 4, from which you se-lect option 2.

Interrupting using 'e' also has the effect that the data are sorted with increasing X (and increasing Y when X's are equal).

```
------------------------------ SD 2 ------------------------------
!                                                                 !
!          - - ORDINARY LINEAR REGRESSION ANALYSIS - -            !
!                                                                 !
! This program performs an ordinary linear regression analysis :!
!                                                                 !
!      Y(i) = intercept + slope * X(i),   i = 1,2,...,n.          !
!                                                                 !
! The input data formats are :                                    !
!                                                                 !
! Option 1: X(i)/Y(i) (one single pair of observations). Notice   !
!           that the symbol '/' is used to separate X and Y       !
!                                                                 !
! Option 2: X(i)/Y(i)*n(i)  (n(i) pairs of equal observations)    !
!           This option may be used for weighting of the obser-   !
!           vations. Thus, n(i) need not to be an integer.        !
!                                                                 !
! Option 3: X(i)/Y(i)+Y(i+1)+...+Y(i+m)  (several pairs of ob-    !
!           ervations all with the same X). The program assigns   !
!           appropriate values to the X-index. I.e. entering      !
!           each pair at a time would be equivalent.              !
!                                                                 !
! Option 4: X(i)/Y(i)*n(i)+Y(i+1)*n(i+1)+...+Y(i+m)*n(i+m)        !
!           I.e. any combination of options 1, 2 and 3.           !
!                                                                 !
! The input data set :                                            !
!   i      1    2    3    4    5    6    7    8    9   10        !
! ---------------------------------------------------------       !
! X(i)     2    3    3    4    4    5    5    5    5    5        !
! Y(i)     4    6    6    7    8    9    9   10   11   11        !
!                                                                 !
! can be entered in the following way :                           !
!  2/4                                                            !
!  3/6*2                                                          !
!  4/7+8                                                          !
!  5/9*2+10+11*2                                                  !
!                                                                 !
! but you could also do it the more elaborate way :               !
!  2/4                                                            !
!  3/6                                                            !
!  3/6                                                            !
!  4/7                                                            !
!  4/8                                                            !
!  ... etc.                                                       !
!                                                                 !
! The program sorts the X's in increasing order.                  !
! Y's with equal X are also sorted in increasing order.           !
!                                                                 !
! Whenever you want, you can take a look at the ordered input     !
! data set. The program offers you the option to stop entering    !
! of data, have them sorted, and then continue the entering       !
! process.                                                        !
!                                                                 !
! At this point of the program execution you may delete incor-    !
! rect data, and to replace them with the correct ones.           !
!                                                                 !
  ---------------------------- SD 2 ------------------------------
```

```
---------------------------- SD 4 -----------------------------
!                                                             !
!       - - ORDINARY LINEAR REGRESSION ANALYSIS - -           !
!                                                             !
!  1 : Continue entering data                                 !
!                                                             !
!  2 : Check input data (and delete observations)             !
!                                                             !
!  3 : Perform regression analysis                            !
!                                                             !
!  4 : Transform data (e.g. for length/weight analysis)       !
!                                                             !
!  5 : Exclude observations from the analysis                 !
!                                                             !
!  6 : Save data ( and results) on disk                       !
!                                                             !
!  7 : Do regression analysis on new data set                 !
!                                                             !
!  8 : Print input data                                       !
!                                                             !
!  9 : Print graph                    REGRAPH                 !
!                                                             !
! 10 : Quit (return to main menu)                             !
!                                                             !
! Choose option (default = 3)  I 2 I                          !
!                                                             !
---------------------------- SD 4 -----------------------------
```

Option 2 in SD 4 displays each observation as you successively scroll through the data lines (see SD 5).

```
---------------------------- SD 5 -----------------------------
!                                                             !
!Options: 'e' :end of examination.  'd' :delete(X,Y). 'h' help !
!  I (obs.no.)    X(i)        Y(i)     weight of Y(i)         !
!-------------------------------------------------------------!
!  1             11.2          3            1    !RETURN!    !
!  2             12.4          3.2          1    !RETURN!    !
!  3             12.4          3.2          1    !RETURN!    !
!  4             13            3.5          2    !RETURN!    !
!                                                End of data  !
---------------------------- SD 5 -----------------------------
```

While using the RETURN to scroll through SD 5 you may delete observations. This is the way to correct a misprint made in SD 3. You delete the misprinted (X,Y) in SD 5 and return to SD 3 (via option 1 in SD 4) and reenter the correct (X,Y)-value.

When SD 5 is completed the menu in SD 4 will reappear and you can continue the entering of data (Option 1) as shown in SD 6.

```
---------------------------- SD 6 -----------------------------
!Print  'e' for sorting and listing or for 'end of data'       !
!                                                  ('h' for help)  !
!Obs. no.  (X,Y) , (X,Y*N) ,(X,Y+Y...+Y), (X,Y*N+Y*N+...+Y*N)  !
!-------------------------------------------------------------!
!    5      ! 13.0/3.7          !                              !
!    6      ! 15.7/4.4+4.8*2    !                              !
!    8      ! 15.8/4.4          !                              !
!    9      ! 17.1/4.8+4.9      !                              !
!   11      ! 18.5/4.9          !                              !
!   12      ! 19.0/5.6          !                              !
!   13      ! 13.5/4.0          !                              !
!   14      ! 19.1/5.9          !                              !
!   15      ! e                 !                              !
!                                                             !
---------------------------- SD 6 -----------------------------
```

When all data have been entered the input process is completed by 'e'. SD 4 will appear and you may want to save the data on diskette by choosing option 6.
But you may also postpone saving on disk until after the execution of the regression analysis. In the latter case the data will be saved together with the results of the analysis.

The regression analysis is executed by using option 3.
The results appear on the screen as shown in SD 7.

```
---------------------------- SD 7 -----------------------------
!                                                             !
!   RESULTS OF REGRESSION ANALYSIS                            !
!                                                             !
!   Example of regression analysis                            !
!                                                             !
!   Number of observations  16                                !
!                                                             !
!   Intercept  a                -0.69815751                   !
!   Std. dev. of intercept       0.35231855                   !
!   Confidence interval of intercept (-1.4556424 , 0.05932737) !
!                                                             !
!   Slope  b                     0.32977093                   !
!   Std. dev. of slope           0.02296990                   !
!   Confidence interval of slope     (0.28038564 , 0.37915622) !
!                                                             !
!   Mean value of X's      15.1375                            !
!   Std. dev. of X's        2.55470155                        !
!   Mean value of Y's       4.29375                           !
!   Std. dev. of Y's        0.87060803                        !
!                                                             !
!   Correlation coeff.  r  0.9677                             !
!                      r*r 0.9364433                          !
!   Confidence interval of r      (0.9071 , 0.9889)           !
!                                                             !
!Do you want the the input data and the results printed (y/n)  !
!                                          default = y !RETURN! !
!                                                             !
---------------------------- SD 7 -----------------------------
```

If the default option is chosen in SD 7 Table 3.1 together with a copy of SD 7 is produced on the printer.

Example of regression analysis

i	X(i)	Y(i)	N(i)
1	11.2000	3.0000	1.0000
2	12.4000	3.2000	1.0000
3	12.4000	3.3000	1.0000
4	13.0000	3.5000	2.0000
5	13.0000	3.7000	1.0000
6	13.5000	4.0000	1.0000
7	15.7000	4.4000	1.0000
8	15.7000	4.8000	2.0000
9	15.8000	4.4000	1.0000
10	17.1000	4.8000	1.0000
11	17.1000	4.9000	1.0000
12	18.5000	4.9000	1.0000
13	19.0000	5.6000	1.0000
14	19.1000	5.9000	1.0000

Table 6.1.3.1. Printer output produced by the default option in SD 7.

To explain the results (SD 7) let n be the number of lines in the input table (e.g. n = 14 in Table 6.1.3.1).

$$\text{Number of observations} = \sum_{i=1}^{n} N(i) = N$$

$$\text{Mean value of X's} = \frac{1}{N} \sum_{i=1}^{n} N(i)*X(i) = X$$

$$\text{Mean value of Y's} = \frac{1}{N} \sum_{i=1}^{n} N(i)*Y(i) = Y$$

$$\text{Std. dev. of X's} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{n} N(i)*(X(i) - X)^2} = \sqrt{Sx}$$

$$\text{Std. dev. of Y's} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{n} N(i)*(Y(i) - Y)^2} = \sqrt{Sy}$$

$$\frac{1}{N-1} \sum_{i=1}^{n} N(i)*(Y(i) - Y)*(X(i) - X) = Sxy$$

slope = Sxy/Sb = b intercept = Y - X*b = a

correlation coefficient = Sxy/(Sx*Sy) = r

Std. dev. of slope = $(Sy/Sx-b^2)/(N-2)$ = Sb

Std. dev. of intercept = $Sb*(Sx*(N-1)/N + X^2)$ = Sa

Confidence limits (95 %) of intercept : a-Sa*t(N-2) a+Sa*t(N-2)
Confidence limits (95 %) of slope : b-Sb*t(N-2) b+Sb*t(N-2)
where t(n) is the students statistics with n degrees of freedom.

Confidence limits (95 %) of correlation coefficient :
tanh(r1-r2) tanh(r1+r2)
where r1 = 0.5*log((1+r)/(1-r)) and r2 = 1.96*V N-3

Data transformation.

The above section of the manual has dealt with the ordinary linear regression analysis. As mentioned in section 1 the program REGRES offers possibilities for several transformations of the data.
If option 4 in SD 4 is selected SD 8 appears.

```
------------------------------ SD 8 ------------------------------
!                                                                 !
!              DATA TRANSFORMATION                                !
!                                                                 !
! 1: log(Y) = a + b*log(X) (e.g. if X = length and Y = weight)    !
! 2: log(Y) = a + b*X                                             !
! 3: Y = a + b*log(X)                                             !
! 4: X = a' + b'*Y          (inverse regression )                 !
! 5: Y/X = a + b*X          (e.g. for surplus production models)  !
! 6: log(1-Y/A) = a + b*X   (von Bertalanffy plot)                !
! 7: Y^A = a + b*X                                                !
! 8: Y = a + b*X^A                                                !
! 9: log(1/Y-1) = a + b*X   (Logistic curve)                      !
!10: Quit (e.g for saving before transformation)                  !
!                                                                 !
! Choose option (default = 10)    ! 1 !                           !
!                                                                 !
------------------------------ SD 8 ------------------------------
```

As an example we consider the weight/length data shown in Table 6.1.3.2. Y is the weight in grammes and X is the length in cm. We want to estimate the parameters q and b in the weight/length relationship : $W = q\,L^b$

For that purpose option 1 in SD 8 is selected. After the transformation SD 8 will contain a notice on the transformation as shown in SD 8 a.

i	X(i)	Y(i)	N(I)
1	10	10	1
2	20	80	1
3	30	270	1
4	40	640	1
5	50	1250	1
6	60	2160	1

Table 6.1.3.2. Weight (Y)/ Length (X) data.

```
------------------------------ SD 8 a ------------------------------
!                                                                   !
! Transformations already made                                      !
!  log(Y) = a + b*log(X)                                            !
!                                                                   !
!                DATA TRANSFORMATION                                !
!                                                                   !
! 1: log(Y) = a + b*log(X) (e.g. if X = length and Y = weight)      !
! 2: log(Y) = a + b*X                                               !
! 3: Y = a + b*log(X)                                               !
! 4: X = a' + b'*Y          (inverse regression )                   !
! 5: Y/X = a + b*X          (e.g. for surplus production models)    !
! 6: log(1-Y/A) = a + b*X   (von Bertalanffy plot)                  !
! 7: Y^A = a + b*X                                                  !
! 8: Y = a + b*X^A                                                  !
! 9: log(1/Y-1) = a + b*X   (Logistic curve)                        !
!10: Quit (e.g for saving before transformation)                    !
!                                                                   !
! Choose option (default = 10)    !RETURN!                          !
!                                                                   !
------------------------------ SD 8 a ------------------------------
```

You may continue making as many transformations on the data as you like (but in this example only one transformation is relevant). E.g. option 2 followed by option 3 is equivalent to option 1.

The results of the regression analysis and the input data are shown in Table 3.3 (Produced by the default option in SD 7.

Thus, b = 3 and q = exp(intercept) = exp(-4.60517) = 0.01

i	X(i)	Y(i)	N(i)
1	2.3025	2.3025	1.0000
2	2.9957	4.3820	1.0000
3	3.4012	5.5984	1.0000
4	3.6888	6.4614	1.0000
5	3.9120	7.1309	1.0000
6	4.0943	7.6778	1.0000

RESULTS OF THE REGRESSION ANALYSIS

Number of observations 6

Intercept a -4.60517019
std. dev. of intercept 0
Confidence interval of intercept (-4.60517019 , -4.60517019)

Slope b 3
std. dev. of slope 0
Confidence interval of slope (3 , 3)

Mean value of x's 3.39912696
Std. dev. of x's .662643494
Mean value of y's 5.5922107
Std. dev. of y's 1.98793048

Correlation coeff. r 1
r*r 1
Confidence interval of r (1 , 1)

Table 6.1.3.3. Input data and results from length/weight analysis.

6.1.4. PRINTER OUTPUT.

REGRES prints out input data and the results as in Table 3.3.

6.1.5. CONNECTION TO OTHER PROGRAMS.

The program REGRAPH, which produces the graph for the regression analysis, uses as input files created by REGRES.

These are of the type " ORDINARY REGRESSION ANALYSIS "

6.2. REGRAPH.

1. PURPOSE.

The purpose of the program REGRAPH is to produce the graph corresponding to a run of the program REGRES.
REGRAPH may also be used to produce the plot of observations without the regression line.

6.2.2. INPUT / INPUT FILE.

Input to REGRAPH must be a file created by the program REGRES i.e. of the type:

" ORDINARY LINEAR REGRESSION "

6.2.3. SCREEN DIALOGUE.

In SD 1 you are asked to specify the dimension of the graph. The default graph size is the screen size, i.e. a graph of 21 lines each of 76 characters.
If you wish you may get a larger graph. The maximum size of graph is 100 lines each of 140 characters (on two separate sheets of paper).
You specify the larger graphs by giving the Y-interval size and the X-interval size on the axis (see SD 1).

The graph is shown on the screen before it is printed.

SD 2 shows a screen size graph (the one corresponding to the example used in the manual for REGRES).

Figure 6.2.4.1. shows a maximum size graph with 500 pairs of (X,Y) (the maximum number).

```
---------------------------- SD 1 -----------------------------
!                                                             !
!        - - ORDINARY LINEAR REGRESSION GRAPH - -             !
!                                                             !
! example regression analysis                                 !
!                                                             !
! Number of (X,Y) pairs  14                                   !
!                                                             !
! Min X            Max X          Min Y          Max Y        !
! ---------------------------------------------------        !
!  11.2            19.1            3              5.9        !
!                                                             !
! By 'return' the graph becomes 'screen-size'                 !
!                                                             !
! Give X interval step     !RETURN!                           !
!                                                             !
! Give Y interval step     !RETURN!                           !
!                                                             !
! Size of graph : (number of X's X number of Y's)=( 74X21)    !
!                                                             !
! Intercept = -.698157509    Slope = .329770934               !
!                                                             !
! Do you want the line superimposed (y/n) Default = y !RETURN! !
!                                                             !
! Is input OK ? (y/n) default = y  !RETURN!                   !
!                                                             !
---------------------------- SD 1 -----------------------------
```

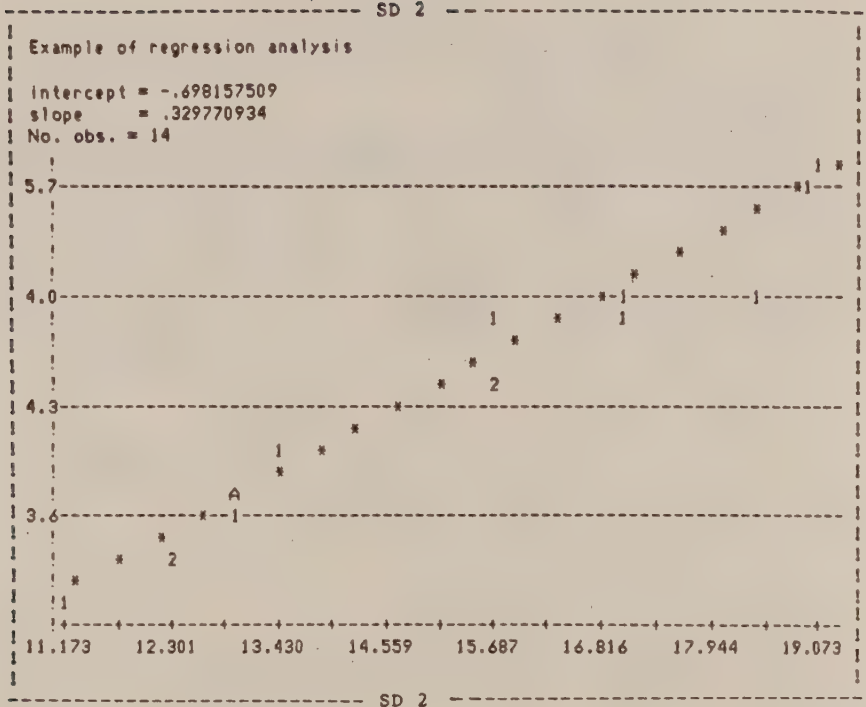
The symbols used on the graph (SD 2) mean :

1 : One observation (one line in the input table)
2 : Two observations (two lines in the input table)
    .....
    .....
9 : Nine observations (nine lines in the input table)
0 : More than nine observations (more than nine lines in the input table)

* : Point on the regression line, where there are no observations.

A : One observation on the regression line.
B : Two observations on the regression line.
    .....
    .....
M : More than nine observations on the regression line.

SD 2



SD 2

6.2.4. PRINTER OUTPUT.

The screen size graph shown in SD 2 and the maximum size of graph shown in Figure 6.2.4.1 are examples of printer output.
The graph in Figure 6.2.4.1 was printed on two sheets of paper which were subsequently joined and reduced in size.

6.2.5. CONNECTION TO OTHER PROGRAMS.

REGRAPH does not produce input files for other programs.

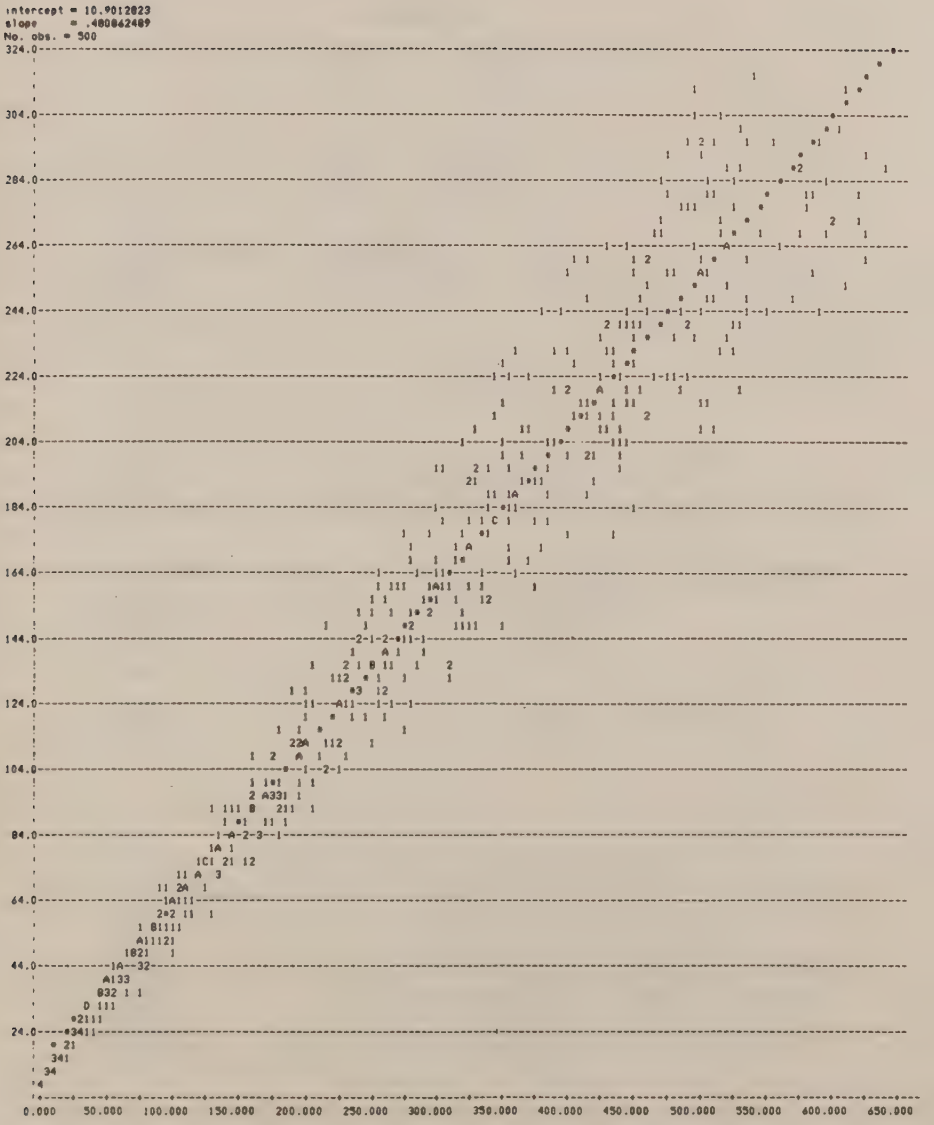


Figure 6.2.4.1. Maximum size graph with 500 pairs of (X,Y)

APPENDIX A.

LIST OF CONTENTS OF PROGRAM DISKETTES.

(October 1986)

STARTUP DISKETTE : (Name : FSA.STARTUP)

(The first four programs are executed automathically)

1.	PRODOS	Disk operating system
2.	BASIC.SYSTEM	BASIC system
3.	EXTRAS	Utility programs (contains the time setting)
4.	STARTUP	Startup program

(Programs 5-18 are ordinary L.F.S.A. program which may be executed by "RUN")

5.	MAINMENU	FSA main menu program
6.	FILEIND	File identification program
7.	LFMENU	Length frequency analysis main menu
8.	VBMENU	AL. 1. Age/length analysis main menu
9.	PAMENU	Parameter input main menu
10.	GENMENU	General purpose program main menu.
11.	VBINPUT	AL. 2. Age/length data entry program
12.	VBMERGE	AL. 3. Age/length data file merging program.
13.	VONBER	AL. 4. Von Bertalanffy parameter estimation.
14.	VBRESU	AL. 5. Results from VONBER
15.	VBGRAPH	AL. 6. Graph for VONBER.
16.	BHYR	PA. 1. Beverton & Holt yield per recruit.
17.	REGRES	GEN. 1. Linear regression analysis.
18.	REGRAPH	GEN. 2. Graph for REGRES.

LENGTH FREQUENCY ANALYSIS DISKETTE NO. 1. (Name : FSA.LF.1)

1.	MENU	LF. 1. Length frequency analysis main menu.
2.	DIMENSION	Dimensioning of L.F. programs.
3.	DIMENSIONDATA	Current dimesions of L.F. programs (TXT file)
4.	LFINPUT	LF. 2. Length frequency data entry program.
5.	LFINF	LF. 3. Additional data entry program.
6.	LFTABLE	LF. 4. Length frequency table program.
7.	LFBAR	LF. 5. Length frequency bar diagram program.
8.	LFSUM	LF. 6. Length frequency summation program.
9.	LFCONV	LF. 7. Length frequency conversion program.
10.	LFMANI	LF. 8. Length frequency data manipulation.
11.	LFMERGE	LF. 9. Length freq. file merging program.

LENGTH FREQUENCY ANALYSIS DISKETTE NO. 2. (Name : FSA.LF.2)

1.	MENU	LF. 1. Length frequency analysis main menu.
2.	DIMENSION	Dimensioning of L.F. programs.
3.	DIMENSIONDATA	Current dimesions of L.F. programs (TXT file)
4.	BHATTAC	LF. 10. Bhattacharya anlysis (Part one).
4a.	BHATTAC0	(part of BHATTAC)
5.	BHATTAC2	LF. 10. Bhattacharya anlysis (Part two).
6.	BHATTAC3	LF. 10. Bhattacharya anlysis (Part three).
7.	MODALGR	LF. 11. Bhattacharya results and graph (part one)
8.	MODALPR	LF. 12. Modal progression analysis and graph (part one)
9.	MODALPR2	LF. 12. Modal progression analysis (part two)
10.	GHBIRTH	LF. 13. Gulland-Holt graph and birthday analysis.
11.	CCURVE	LF. 14. Length converted catch curve analysis.
12.	BHZWET	LF. 15. Beverton & Holt' Z equation and Wetherall et. al. analysis.
13.	JONZAL	LF. 16. Jones & van Zalinge analysis.
14.	LCOHOR	LF. 17. Length converted cohort analysis.

APPENDIX B

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APPENDIX C.

LIST OF APPLESOFT BASIC AND PRODOS STATEMENTS USED IN THE LFSA PACKAGE

APPLESOFT BASIC :

Arithmetic operators :

=	Assigns value to variables
+	Addition
-	Subtraction
*	Multiplication
/	Division
!	Exponentiation

Relational operators :

=	Is equal to
<	Is less than
>	Is greater than
<= =<	Is less than or equal to
>= =>	Is greater than or equal to
<> ><	Is not equal to.

Logical operators :

AND	Both true
OR	Either or both true

Arithmetic functions :

ABS(X)	Absolute value of X
INT(X)	Integer part of X
SQR(X)	Square root of X
EXP(X)	Exponential of X
LOG(X)	Natural logarithm of X

Statements and lines :

:	Separates multiple statesments on same line.
REM	Remarks for human reader

Control :

GOTO n	Branches to line n
IF cond THEN s1:s2:s3...	Executes statements s1,s2,s3,... if condition cond is true
FOR v = x TO y STEP z	Begins loop for all values of v from x to y by z. If STEP is omitted, 1 is understood.
NEXT v	Repeats loop for next value of v
GOSUB n	Branches to subroutine at line n
RETURN	Returns from subroutine to point of call
ONERR GOTO n	Establishes error-handling routine beginning at line n
STOP	Halts execution with message identifying line.

```
String operations :
+            Concatenates strings
LEN(s)       Length of string s
LEFT$(s,x)   Leftmost x characters of string s
RIGHT$(s,x)  Rightmost x characters of string s
MID$(s,x,y)  y characters beginning at position x in string s
STR$(x)      String representing numeric value x
VAL(s)       Numeric value of string s
CHR$(x)      Character with ASCII code x

Operations on whole programs :
CLEAR        Resets all variables
LOAD name    Loads program "name" from disk

Variables :
TYPE         NAME              RANGE
Real         AB          +/- 9.99999999 E+37
Integer      AB%         +/- 32767
String       AB$         0 to 255 characters
Where A is a letter, B is a letter or a digit.
Name can be more than two characters, but only two first are
significant.

Arrays :
TYPE              TYPICAL ELEMENT
Real         AB(x,y,z)   AB(x,y)   AB(x)
Integer      AB%(x,y,z)  AB%(x,y)  AB%(x)
String       AB$(x,y,z)  AB$(x,y)  AB$(x)
DIM a(x,y,z)     Defines array a with maximum subscripts x,y,z

Input/output :
INPUT s;x,y,z  Promts with string s, then reads values into
               variables x,y,z. If s is omitted, ? is used.
READ x,y,z     Reads values from DATA list into variables x,y,z
DATA x,y,z     Adds values x,y,z to DATA list
PR#n           Sends output to slot n
PR#0           Sends output to display screen
PRINT x,y,z    Displays or prints values x,y,z
HOME           Clears screen and send cursor to top
TAB(x)         Moves cursor to column x (PRINT statement only)
VTAB x         Moves cursor to line x
INVERSE        Displays text in black-on-white
NORMAL         Displays text in white-on-black

Utility statement :
PEEK(addr)     Content of memory addr (only used in connection
               with ONERR GOTO)
```

PRODOS COMMANDS :

To use a prodos command within a BASIC program you must print a string consisting of a CONTROL-D as the first thing on a printed line, followed by the command. You obtain that by (e.g.)

```
100 PRINT CHR$(4);"prodos command"
```

CHR$(4) returns CONTROL-D.
The prodos command is written in quotation marks, E.g. :

```
100 PRINT CHR$(4);"CAT"
```

produces a listing of the disk directory.

The following commands were used :

RUN program name, (D1 or D2)
LOAD program name, (D1 or D2)
OPEN file name, (D1 or D2)
CLOSE file name
READ file name
WRITE file name

Only sequential access files were used

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Computer programs for fish stock assessment

LENGTH-BASED FISH STOCK ASSESSMENT
FOR APPLE II COMPUTERS

REQUEST FOR DISKETTES:

LENGTH BASED FISH STOCK ASSESSMENT:

Type or use block letters:

Name: .....

Job title: .....

Organisation: .....

Department: .....

Address: .....

.....

..... Country: .....

Telephone: .....

Telex: .....

Version required:

Apple II, PROPOS (3 blank diskettes in exchange)

IBM , MS-DOS (3 blank diskettes in exchange)

Addresses:

F A O
Fisheries Department
Marine Resources Service
Via delle Terme di Caracalla
00100 Rome, Italy

The programmes should also be soon available from Computer Users' networks such as:

ICLARM International Center Living Aquatic Resources Management, P.O. Box 1501 - Makati, Metro Manila

AFCUS American Fisheries Society Computer Users Sections Washington Dept of Game - 600 N.Capital Bay Olympia W.A. 98504 - USA

SESAME South-Eastern Softwore and Message Exchange North Carolina State University - Institute of Statistics - Roleigh Division - Box 8203 N.C. 27 695-803

Fisheries Software Register. IOTOS Pty Ltd - P.O. Box 19 Margate - Tasmania 7153 - Australia

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